Australian Government | National Landcare Program

Smart Farming Partnerships – Round 1

Final Report

Application ID:	SFP1-130
Grantee Name:	Queensland University of Technology
Project Title:	Unlocking The True Value of Organic Soil Amendments, An Innovative Farm- Ready Tool for The Effective Management Of Manures and Composts into Farm Fertiliser Budgets for Environmental, Soil Health and Economic Sustainability.
Grantee contact person who prepared the report:	David Rowlings
Report authorised by (Grantee):	
	Date: 30/03/2023
Date submitted	30/03/2023

- *Where there are text fields – Space can be increased or deleted as required to accommodate information to be reported.*
- *Please send the completed report to:* landcare@agriculture.gov.au

Due Date

The due date is specified in section C of the Grant Agreement.

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Project Description Use this section to summarise the purpose or objective(s) of the Activity
The integration of plant nutrients released from organic soil amendments into farm fertiliser budgets allows not only for the reduction of synthetic fertiliser rates without compromising crop yield, but also multiple environmental and soil health co-benefits. This project provided farmers, agronomists and suppliers of manures and composts with a decision support tool for integrating organic amendments into farm nutrient budgets. On-farm field validation and demonstration sites from the Queensland to Victoria across vegetables, cotton, cropping and pasture showcased the tool and provide case studies of reduced fertiliser use and cost reductions, yield benefits possible from using organic amendments, and potential additional soil health and sustainability benefits. The manure and compost nutrient calculator is freely available as a farmer-friendly web and smart phone application.

Overview of Project delivery

Executive summary

Benefits of this research to Australian agriculture

Overall the project tested 65 different organic amendment types across 20 different field trials over four years. Sites were located from Roma in Queensland, through to Geelong in Victoria, spanning the beef, dairy, irrigated and dryland cropping and intensive horticultural industries. A common methodology was used across the sites, a combining laboratory analysis and farmer field trial and demonstration sites. The Organic Amendment Nutrient calculator was developed using the data generated from the lab and field analysis, and incorporated farmer feedback from the workshops. The calculator is free to use as a web or phone based application, and provides farmers with a one-stop resource for using organic amendments. It allows farmers to easily tap into the OA nutrient database generated by the project to predict how the supply of nutrients from the OA will meet the plant requirements from a range of key Australian crops, and compare the prices with conventional fertiliser. The calculator can be found here: https://oa-nutrient-calculator.netlify.app/.

As well as developing the calculator the project engaged with OA generators such as feedlots, composters, agronomists, state government regulatory bodies and of course farmers to demonstrate the advantages and challenges of incorporating OA's into farm nutrient budgets. Over the four years the project conducted 14 farmer/industry workshops, 12 conference seminar or webinars, 10 newsletter or media releases, 8 on-farm field tours and 7 scientific papers or conference proceedings.

The project had 5 major themes, broken down into the activities of 1) overarching project management, 2) OA generators (Producers, handlers, and suppliers) data collection and extension, 3) Cotton and Irrigated broadacre crops research, demonstration trials and extension, 4) Southern Vegetable systems and intensive horticultural crops research, demonstration trials and extension, 5) Northern Systems and winter grain crops research, demonstration trials and extension and 6) Nutrient release curve calculator/phone application from various organic amendments and soil types. The major findings, benefits to Australian agriculture and outcomes for policy makers are as follows:

1) The variability of OA products remains the key barrier to their wider incorporation into farm nutrient budgets. Even using best practice of nutrient testing, there is a mismatch between how they are sold, transported and applied (per meter cube fresh weight), and how their nutrient contents are reported (kg per dry weight). As such moisture content and bulk density are the two largest variants of what ends up on the farmer field – and neither are reported well.
2) Across all trials, yields from all trails responded either conventional fertiliser or organic amendments, with the dryland trials showing the least response and irrigated the most. Organic amendments increased biomass yield by 15% compared to unfertilized plots, and overall increased biomass by 8% across all treatments. Accounting for the nitrogen applied in the OA's led to a small gain in biomass overall (+4%), but with wide variations between individual crops. Distinct multi-year benefits were only evident in two of the trials, with variations in crop rotation and seasonal conditions masking any benefits at the other sites.
3) In the heavy clay soils of the irrigated cotton growing areas, OA's may preserve co-applied urea- N which could be available for use by subsequent rotational crops, an important consideration for medium term crop management. Cotton yield increased with annual poultry litter application, generating an additional potential income of $2000/ha over three years.
4) Trials in high-value horticulture confirmed that organic amendments (OA) are a valuable source of nutrients for early crop production, and accounting for these nutrients could reduce fertilizer inputs by up to 60% while maintaining yield. This benefit saved growers up to $2,600 /ha/year in fertilizer costs and improved nitrogen-use efficiency, as well as increasing soil health. However this came at an environmental cost – with the combination of OA's and mineral fertiliser increasing N_2O (potent greenhouse gas) by up to 50%.
5) Trails in the broadacre dryland cropping and fodder showed a more varied response to OAs as yields were driven more by seasonal conditions. However the large-scale field trials showed that combined use of OAs with reduced mineral fertilizer rates can provide yields that are similar to those obtained with standard mineral fertilizer application rates.

Key findings for policy makers and the Australian agricultural industry

This project again made very clear and promoted that using OAs needs to move away from a 'waste disposal' mindset to one of nutrient and soil management. This includes the need for farmers to have meaningful analytical test results for OAs they are going to use, as well as the use of appropriate spreading equipment that achieves satisfactory product distribution at the set rate.

The standardisation of research into national and cross-industry consistent and compatible frameworks, methodologies and databases is critical for addressing the wicked issues of sustainable food production and resource management. Clearly defining the trade-offs and benefits of organic amendments for Australian agriculture is becoming more critical as the de-carbonisation of the economy looks to divert OA's away from traditional disposal practices like land application (for manures) or landfill (for FOGO) and into bioenergy. Only by assessing the true-value of these OA's for nutrition and soil health can adequately informed polices be developed.

Unanswered questions and next steps

This project made some key steps towards unlocking the true value of organic amendments. Several questions remain, all of which point towards the need for long term trials. This project covered some of the driest, and wettest years in Australian history, but even then it didn't cover the range of crop rotations, management and climatic conditions experienced on the average farm. Permanent, long-term trials are required to better understand the interaction OA nitrogen and synthetic urea nitrogen has on nitrogen mineralisation throughout the season, and can this be used to further reduce N rates without compromising yield or quality.

The environmental life-cycle assessment of using OA's needs to be further explored. In our intensive horticulture trials, the use of OA with mineral fertilizers increased emissions of nitrous oxide from soil to the atmosphere by up to 50% across diverse soil-types and production systems, compared with fertilizers alone. Uncontrolled, this will have significant impacts on the environment in terms of global warming and stratospheric ozone degradation. Further research and lifecycle analysis are urgently required on ways to minimize and mitigate the release of nitrous oxide from soils treated with OA and inorganic fertilizers, which may include easy-to-adopt solutions such as the application of nitrification inhibitors, slow-release products, organo-mineral fertilizers, and the timing of OA and fertilizer application. The trade-offs of potential more N_2O versus soil carbon sequestration benefits also need to be considered.

As longer-term trials in Europe have shown that nitrogen use efficiency from annual compost use increases from 0 – 5% in the initial 3-4 year period to 10 - 20% after 10 to 12 years, the establishment and adequate monitoring of several longer-term field trial sites in Australia, containing large and small plots, where several OAs are applied, would provide the much needed platform for determining and verifying of both macro and micro nutrient (N, P, K, Ca, Mg, Zn) supply and use efficiency, but also the effects on annual OA application on physical soil properties and soil microbial communities and their combined effects on soil health.

Did the project achieve all contracted activities, measures and outcomes as described in the Project Work Plan and any amendments?	**Yes** ☒	**No** ☐
If NO, please explain why not everything was delivered.		
Have you had any major incidences which required risk management and implementation of mitigation strategies as outlined in your Risk Management Plan in the Work Plan?	**Yes** ☒	**No** ☐
If YES please explain these and what the implications were.		
QUT – Covid/Drought extension for a year		

Project Administration

Please provide a summary of project administration activities undertaken during the reporting period e.g. progress towards implementing the Activity Plan; appointment of or changes to Activity staff; establishment of agreements/contracts with Activity participants, compliance with terms and conditions of the Grant Agreement.
QUT

Project Activities Use this section to provide details of how the Project activities were conducted including any unanticipated events or technical/resourcing difficulties and how these were overcome. If there was a need to change the Project activities, please explain how this change was incorporated into the Project as well as reflected in the Project WorkPlan, and if this affected the outcomes of the Project.

Explain how each Project activity contributed to the Project objectives as listed in your WorkPlan, including metrics if relevant (e.g. hectares impacted, number of landholders impacted etc.). Where possible include evidence of activities (e.g. data, photographs etc.) and list any communications materials that resulted from the activity. These activities should match those listed in your Project WorkPlan and budget template.

Project Activity 1 (as listed in your WorkPlan) Overarching project (Queensland University of Technology)	
What did you do?	Project strategy, methodological design, overall coordination, capacity building
How did you do it?	Regular web conferences and meetings, site tours, one-on-one conversations and site visits (individual composters and farmers) Training of interns and post-graduate students
When did you do it?	Monthly web-meetings Annual face-to-face meetings (except during 2020-21 due to COVID) Regular site visits and discussions with farmers and OA generators
Who participated?	All research consortium partners. (QUT) Assoc Prof David Rowlings (Project Chief Investigator) Dr Daniele de Rosa (methodology development) Dr Naoya Takeda (modelling and App development) Dr Mark Bonner (statistical modelling) Anabelle Ramsay (Project Manager) Ben Vickery (PhD student) Gabrielle Torrisi (Masters student/lab tech) Sandra McEwan (Masters student) Jemika Dearberg (intern) Centre for Recycling Organic Wastes and Nutrients- University of QLD Johannes Biala (OA generators) Latrobe University Prof Ian Porter (Industry liaison) David Riches (Principal investigator southern vegetable systems)

	Dr Scott Mattner (Industry extension) Deakin Assoc Prof Wendy Quale (Principal investigator irrigated/cotton systems) Dr Jackie Webb (OA N interaction in cotton) Dr Rakesh Awale (OA phosphorus interactions) Industry partners - MLA program leads - Manufacturers of manure-based (Organic Nutrients) and urban-derived (Candy Soil, Peats Soil & Compost Supplies) compost products - State Government bodies (NSW EPA, Green Industries SA)
Who will delivered the activity?	All consortium partners listed above
What was the output? *How did this contribute to Program objectives listed in the WorkPlan?*	Common methodologies throughout the project, collated databases from all field sites and OA's used. Joint research outputs, extension material and conference presentations.
What evidence can you provide? (e.g photographs?	 

Project Activity 2 (as listed in your WorkPlan) OA generators (Producers, handlers, and suppliers) data collection and extension (University of Queensland and Queensland University of Technology)	
What did you do?	Collation of an organic amendment (OA) database that contains nutrient analysis and key characteristics of different OA products that were used in field and lab trials. Upstream OA management and handling data were collected where possible.
How did you do it?	65 different organic amendments were assessed over the project. Each OA was analysed for chemical characteristics including total and available macro and micronutrients at EAL, Lismore. Field days and roadshows were used to communicate with the composting and OA industry
When did you do it?	Organic amendments were analysed throughout the project as they were utilised in field, glasshouse and laboratory trials.
Who participated?	All research consortium partners (see above)
Who will delivered the activity?	All research consortium partners (see above)
What was the output? *How did this contribute to Program objectives listed in the WorkPlan?*	OA nutrient database describing the OA feedstock, animal type, treatment (i.e. composted) and the macro and micronutrients.
What evidence can you provide? (e.g photographs?	https://oa-nutrient-calculator.netlify.app/resources

<table>
<tr><td colspan="2">Project Activity 3 (as listed in your WorkPlan)

Cotton and Irrigated broadacre crops research, demonstration trials and extension (Deakin University)</td></tr>
<tr><td>What did you do?</td><td>Optimised the management of poultry litter high yielding surface irrigated cotton production systems in The Riverina.
Defined optimal poultry litter application rates integrated with conventional crop nutrient budgets in different irrigated soil types to offset and reduce the application of urea-N and mineral P fertilizers whilst maintaining or improving yield. Outcomes were demonstrated to industry and growers at commercial scale and potential farm economic benefits were highlighted.

Whitton: (34°32’S, 146°11’E). 2017-2020 Cotton.
The trial was conducted at commercial scale on a total area of 7.2 ha with cotton being grown as a summer crop in each year alternated by winter fallow. In the previous years the site had grown barley-cotton-soybeans. Ground preparation, irrigation, planting, poultry litter spreading, plant growth regulation, defoliation, pest management, harvesting were all done according to commercial practise and with commercial implements. Subsidiary manual harvest picks (3 x 2m of crop row) were also undertaken. The plots consisted of twelve, 310 m long plant rows spaced 1 m apart. The experiment was a randomised blocked design; a control, urea and non-composted poultry litter rates with matched N were the main plots with three replicates. The poultry litter treatments were applied to the same plots consecutively for 3 years in the Austral winter (August, 2017, June, 2018, September, 2019) and pre-plant fertilizer was applied 1-2 months prior to sowing. Some variation occurred in mineral fertilizer applications according to farmer decisions. In this study PAN was calculated using an assumption that 55% of organic N in the litter mineralised in the first year and was estimated using the equation: PAN = (TN -Ni) = No. (No*0.55)+ Ni adapted from Bitzer and Sims (1988).</td></tr>
</table>

Year/Treatment	Pre-plant Fertilizer-N	Poultry litter-N	Top-dress urea-N	Total plant available N
2017				
Control	**0**	**0**	**0**	**0**
Low Fertilizer	**100**	**0**	**50**	**150**
High Fertilizer	**100**	**0**	**90**	**190**
Fertilizer + 4t/ha PL	**100**	**55**	**50**	**205**
Fertilizer + 8t/ha PL	**100**	**110**	**0**	**210**
Fertilizer + 16t/ha PL	**0**	**220**	**0**	**220**
2018				
Control	**90**	**0**	**0**	**90**
Low Fertilizer	**140**	**0**	**0**	**140**
High Fertilizer	**140**	**0**	**160**	**300**
Fertilizer+4t/ha PL	**140**	**55**	**100**	**295**
Fertilizer+ 8t/ha PL	**140**	**110**	**50**	**300**
Fertilizer +16t/ha PL	**90**	**220**	**0**	**310**
2019				
Control	**0**	**0**	**0**	**0**
Low Fertilizer	**100**	**0**	**40**	**140**
High Fertilizer	**100**	**0**	**180**	**280**
Fertilizer+4t/ha PL	**100**	**70**	**110**	**280**
Fertilizer+ 8t/ha PL	**100**	**140**	**40**	**280**
Fertilizer +16t/ha PL	**0**	**280**	**0**	**280**

Whitton: Fertilizer/Manure treatments

Widgelli: The study was conducted during 2017/18 and 2018/19 seasons on a commercial cotton field at Widgelli (34°12'0'' S, 146°5'60'' E).

The experimental design was a generalised randomised complete block, comprising a factorial combination of two landformed (cut) soils and five treatments.

Two 80 m long x 7.4 m wide landformed blocks were established by removing 5 cm (light-cut) or 20 cm (heavy-cut) of topsoil using an excavator with a grading bucket. Each landformed block was divided into 15 suplots to include five treatments with three replications. Individual subplot measured 10.0 m long x 3.7 m wide and consisted four cotton-hills, spaced 0.91 m apart. The treatments were (i) control (no fertiliser applied), (ii) chemical fertilisers supplying 100% N plus P, S, and Zn (CF100), (iii) 70% N supplied from urea and 30% N from PL (CF70PL30), (iv) 30% N supplied from urea and 70% N from PL (CF30PL70), and (v) 100% N supplied from PL (PL100).

	The four fertilised treatments (i.e., except control) were applied at a target N-rate of 250 kg ha-1 in 2017/18, and all treatments were continued in the same subplot in the following 2018/19 season but the target N-rate was increased to 280 kg ha-1 as often practiced by irrigated cotton growers in order to potentially maximise crop productivity upon predicted favourable weather conditions (Rochester, 2011; Macdonald et al., 2015). For both growing seasons, about 55% of total PL-N were assumed to be plant available for all the PL amended treatments (Adeli et al., 2016). For CF100 treatment, urea supplied about 240 kg N ha-1 in 2017/18 season and 253 kg N ha-1 in 2018/19 season. **Benerembah**: (34° 23' 19.536"S, 145° 55' 15"E), located near Griffith in the Murrumbidgee Valley, NSW Australia. The experimental design was a randomised block design of 1 x 2 m open microplots which were buffered by 3 plant rows (4 furrows) to prevent the exchange of labelled urea (Silvertooth et al., 1998). These were replicated four times on treatments amended with or without PL (equivalent to 15t ha-1) across four N application rates (0, 50, 150, and 300 kg N ha-1 ^{15}N labelled urea). Litter was hand spread in 2 m sections on the surface of plant hills, with an 11 m buffer on either side of the microplots, which was machine incorporated (0 – 0.3 m) by the farmer using a bedformer three days later, equivalent to 7 weeks before sowing. Urea was applied using a 50 mL syringe fixed with 20 cm long irrigation pipe and was placed 0.2 m below the top of the plant line, injecting 0.2 m into the soil. Microplots received a total of 500 mL of urea solution each time, made up to the appropriate N rates, given in 25 mL doses every 0.1 m along the 2 m hill row. Each treatment received three split applications of labelled urea of 50% of the total rate at 5 days after sowing (DAS), and 25% at 57 and 82 DAS, respectively. Soil temperature and matric potential were continuously monitored across four of the control microplots from 22 October 2020 (one week following plant establishment) to 3rd April 2021 (defoliation). Measurements were made using one-wire temperature shielded sensors (Model DS18B20) and Watermark sensors for soil water tension (Model 200SS, Irrometer Company Inc., California, USA). At each microplot, one temperature and Watermark sensor was deployed at 0.20 m below the hill row surface and measurements were recorded every hour. The soil matric potential was calculated using the resistance measured and the soil temperature based on equations in Irrometer, 2021. **Gundaline Station Carrathool:** (34°26'48'' S, 146°29'47'' E), about 57 km east of Hay, NSW, Australia. In January 2020, 2.5 Mg ha-1 gypsum ($CaSO_4$) was spread across the entire area in order to ameliorate soil sodicity (Sale et al., 2021). Eighteen 812 m long x 24 m wide plots were laid out in a randomized complete block design (RCBD) to include six treatments with three replicates each. Each replicate plot consisted of 16 cotton beds shaped into two camel-humps, comprising 32 cotton rows, spaced 0.75 m apart. The treatments were different combinations of inorganic and organic P-fertilizers that include (i) control or no P applied, (ii) 150 kg ha-1 MAP, supplying 34 kg ha-1 available P, (iii) 150 kg ha-1 MAP + 4 Mg ha-1 PL, together supplying 60 kg ha-1 available P, (iv) 4 Mg ha-1 PL, supplying 26 kg ha-1 available P, (v) 10 Mg ha-1 PL, supplying 65 kg ha-1 available P, and (vi) 15 Mg ha-1 PL, supplying 98 kg ha-1 available P (Table 2). Whilst the 150 kg ha-1 MAP treatment in this study resembles the standard farmer practice of P nutrition for irrigated cotton production within the

	region, different PL amendment rates chosen were intended to provide P at or above the recommended rate (10–30 kg ha-1 P) for optimal cotton production (CRDC, 2021a) assuming that all of the PL-derived Colwell-P (77% of total P, Table 2) were plant available (Peirce et al., 2013). In January 2020, 2.5 Mg ha-1 gypsum ($CaSO_4$) was spread across the entire area in order to ameliorate soil sodicity (Sale et al., 2021). Eighteen 812 m long x 24 m wide plots were laid out in a randomized complete block design (RCBD) to include six treatments with three replicates each. Each replicate plot consisted of 16 cotton beds shaped into two camel-humps, comprising 32 cotton rows, spaced 0.75 m apart. The treatments were different combinations of inorganic and organic P-fertilizers that include (i) control or no P applied, (ii) 150 kg ha-1 MAP, supplying 34 kg ha-1 available P, (iii) 150 kg ha-1 MAP + 4 Mg ha-1 PL, together supplying 60 kg ha-1 available P, (iv) 4 Mg ha-1 PL, supplying 26 kg ha-1 available P, (v) 10 Mg ha-1 PL, supplying 65 kg ha-1 available P, and (vi) 15 Mg ha-1 PL, supplying 98 kg ha-1 available P (Table 2). Whilst the 150 kg ha-1 MAP treatment in this study resembles the standard farmer practice of P nutrition for irrigated cotton production within the region, different PL amendment rates chosen were intended to provide P at or above the recommended rate (10–30 kg ha-1 P) for optimal cotton production (CRDC, 2021a) assuming that all of the PL-derived Colwell-P (77% of total P, Table 2) were plant available (Peirce et al., 2013). Plant and soil sampling we conducted over the season. A follow up study on a wheat crop that was planted in the winter following the cotton was undertaken to assess residual effects of poultry litter amendments (4 t/ha PL, 10 t/ha PL, 15 t/ha PL, and 4 t/ha PL + 150 kg/ha MAP) and chemical P fertiliser (150 kg/ha MAP) applied to previous cotton crops (2020) on soil nutrient availabilities and crop (wheat) productivity in the following year (2021). Vixen-wheat, an Australian Hard milling variety, was planted in 30-cm rows with 16275 plants per hectare on 23 June 2021. Urea at 116 kg N/ha was applied across all plots, with 12 kg/ha N supplied upfront at planting and the remainder 104 kg/ha N in crop-season. Similarly, all plots received 27 kg/ha P as mono-ammonium phosphate (120 kg/ha MAP) at planting. Weeds, pests, and irrigation were managed as commercial practise. Project outcomes were regularly communicated to industry through IREC annual industry field days, CottonInfo seasonal farm walks, CeRRF Griffith, Deakin University industry networks, IREC Farmers Newsletter, Spotlight Magazine (CRDC), international journal papers (Agronomy J and Nutrient Cycling in Agroecosystems), Australian and NZ Soil Conference (Remote 2020) and Australian Agronomy Conference (Remote 2021).
How did you do it?	Through micro plot, small plot and commercial scale, on-farm trials on large Riverina surface irrigated cotton enterprises and at the IREC Research Station, Whitton. Plant and soil analysis were undertaken at Environmental Analysis laboratory, Lismore NSW using standard soil and manure analysis methods. Farmer communications in conjunction with CeRRF Deakin University professional industry networks, Irrigated Research and Extension Committee – Farmers Newsletter, Australian Cottongrower Twitter: cerrf_griffith and UnlockSoilOAs

When did you do it?	Whitton- 2018-2021 Widgelli – 2018-2020 Benerembah - 2020-21 Gundaline Station – 2018-2020
Who participated?	Chris Morsehead, Owner, Amberley Farms, Widgelli + Yenda Producers (agronomic consultants) Customised Farm Management, Gundaline Station. Darrel Fiddler, Manager, De Bortoli Farms, Benerembah Irrigation Research and Extension Committee (IREC), Whitton with more than 80 farmer and industry members. CeRRF, Deakin University, Griffith Environmental Analysis Laboratory, Southern Cross university, Lismore, NSW
Who will delivered the activity?	Deakin University
What was the output? *How did this contribute to Program objectives listed in the WorkPlan?*	Manure and soil samples collected and sent to QUT for incubation studies for nutrient release determination and analysis. Soil and plant chemistry datasets for 4 field sites. Communication materials (fliers, farmer press articles, Stakeholder Powerpoint presentations, field walk demonstrations, field days, conference presentations, journal papers for extension and research purposes.

What evidence can you provide? (e.g photographs?	    

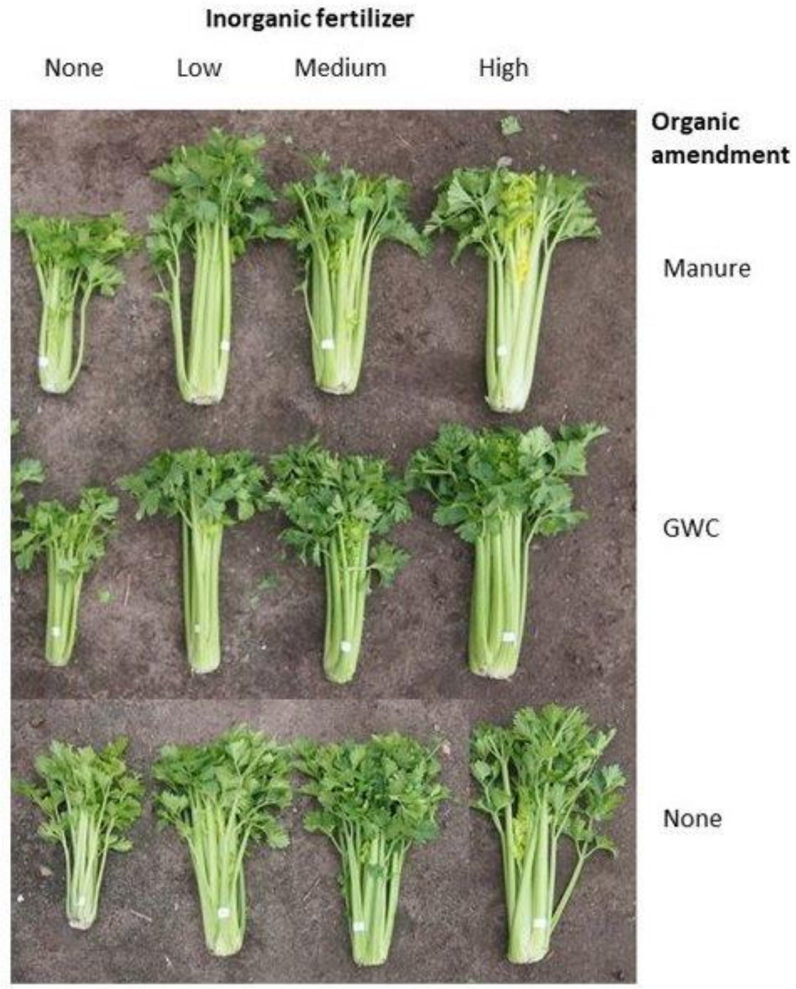
Project Activity 4 (as listed in your WorkPlan) Southern Vegetable systems and intensive horticultural crops research, demonstration trials and extension (La Trobe University)	
What did you do?	Field trials were conducted at 3 sites in Victoria to evaluate the integration of organic amendments into farm fertilizer budgets. Two trials were conducted in major vegetable productions areas (Werribee and Baxter Victoria) and the third site was in the strawberry runner nursery industry region of Toolangi, Vic. In addition to crop yields and soil nutrition and health, greenhouse gas (GHG) emissions were continuously monitored at 2 of the sites (Baxter and Toolangi) for at least 1 growing season for a subset of the treatments.
How did you do it?	Trials included treatments where a portion of the inorganic fertilizer program was replaced by organic inputs, based on modelled predictions of the nutrient calculator. Inorganic fertilizer only and untreated plots formed the controls. OAs were applied on an annual basis and longer-term nutrient release was monitored for subsequent crops. Crop yield, plant biomass accumulation and soil mineral nitrogen was monitored for each trial. GHG gas emissions were measured at two of the sites (Baxter and Toolangi) using a 12 chamber automated GHG measurement system. The automated chamber system provided 8 daily GHG emission measurements from 4 treatments for the entire crop rotation. At the conclusion of the trials, effects of organic amendment application on several soil health indicators were determine at each site.
When did you do it?	Trials were conducted at Werribee and Baxter between 2019 and 2022 while the trial at Toolangi was conducted between 2011-2022.
Who participated?	Trials were conducted by La Trobe University with assistance from grower co-operators. Other organisations that participated in the trials included: VegNET, AusVeg, Food & Fibre Gippsland, Soil Wealth (national vegetable extension organisations); Berries Australia, Victorian Strawberry Industry Development Committee (berry extension organisations); Toolangi Certified Strawberry Runner Growers Committee, Victorian Strawberry Industry Certification Authority

	(strawberry nursery organisations); Incitec Pivot Fertilizers (fertilizer company); and individual vegetable and strawberry growing businesses.
Who will delivered the activity?	La Trobe University with regular input and assistance from the wider project team.
What was the output? *How did this contribute to Program objectives listed in the WorkPlan?*	Project outputs are listed below. Data outputs from the project showed that the use of OA and reduced inorganic fertilizer applications (based on the estimated release of nutrients from OA using the nutrient calculator) produced equivalent crop yields to full fertilizer programs. This resulted in annual fertilizer savings of 34-120 kg N ha or$252-$2,600/ha (based on 2023 fertilizer prices). Results showed that organic amendment type had a large effect on nutrient supply to the crop. Generally chicken manure showed a much higher capacity to supply the crop with nitrogen and produced higher crop yields than urban derived composts (largely composed of green waste material). There were higher total N_2O emissions where OA (chicken manure) was used in combination with inorganic fertilizer compared to inorganic fertilizer alone (see below).
What evidence can you provide? (e.g photographs?	

Werribee Year 1

Baxter Year 1

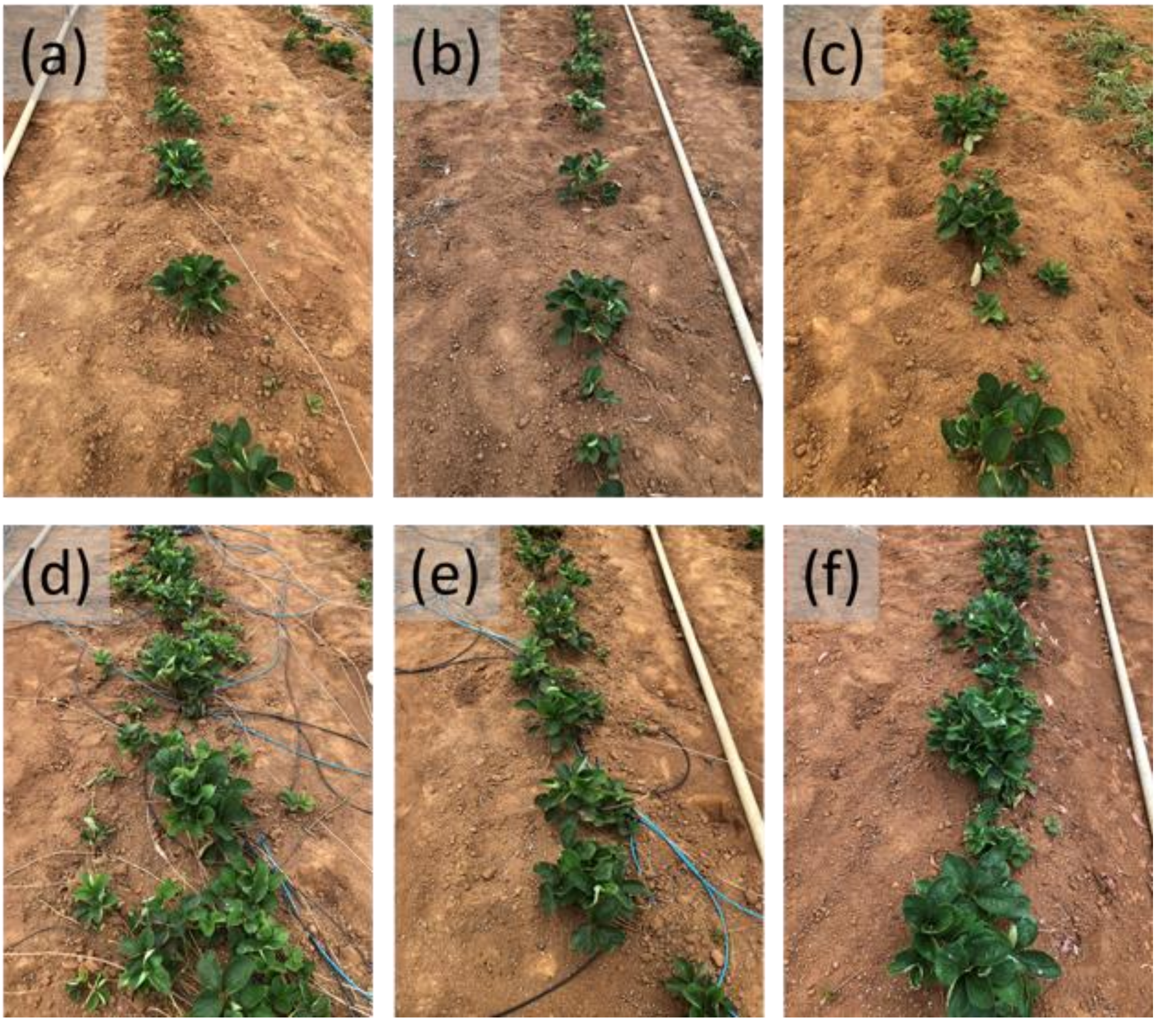
Werribee Year 2



Baxter Year 2

Werribee Year 3

Baxter Year 3



Strawberry runner growth at 3-months after planting in a trial at Toolangi, Victorian in plots treated with (a) no fertilisers, (b) chicken manure, (c) lower rate fertiliser (140 kg/ha), (d) lower rate fertiliser (140 kg/ha) and chicken manure, (e) full rate fertiliser (200 kg N/ha), and (f) full rate fertiliser (200 kg N/ha) and chicken manure

Toolangi Year 1

Toolangi Year 1

<table>
<tr><td colspan="2">Project Activity 5 (as listed in your WorkPlan)

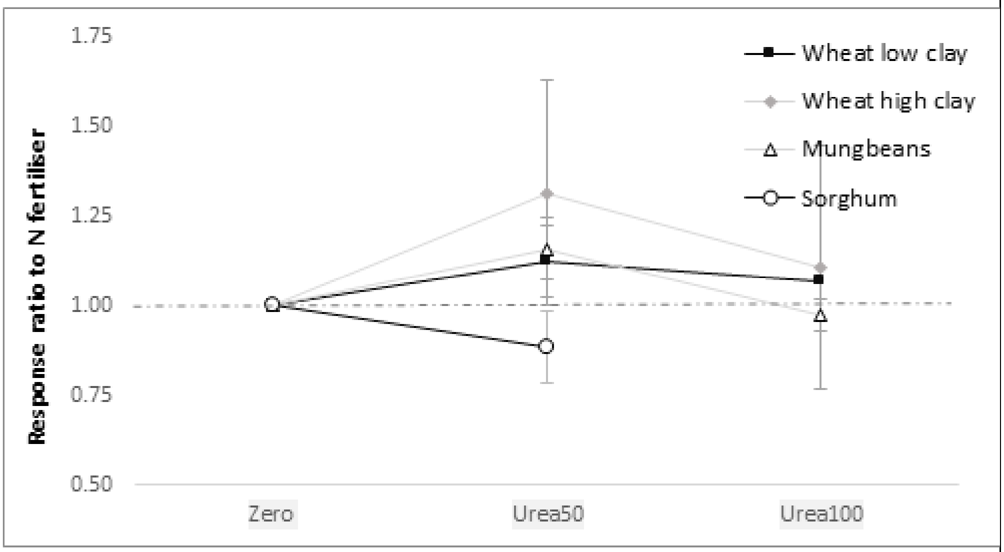
Northern Systems and winter grain crops research, demonstration trials and extension (Queensland University of Technology and University of Queensland)</td></tr>
<tr><td>What did you do?</td><td>List sites, systems & treatments,

- Mulgowie (SEQ)– intensive horticulture
- Felton (Darling Downs)– dryland cropping
- Djuan (Darling Downs)– cut and carry dairy (fodder)
- Roma (Maranoa) – beef fodder cropping
- Freshwater Creek (Geelong) – High-rainfall dryland cropping
- Langhorn Creek (Strathalbyn) – Medium rainfall dryland cropping
- Wagga Wagga – grain / fodder cropping
- Goovigen (Biloela) - lucerne / mixed species hay</td></tr>
<tr><td>How did you do it?</td><td>The aim of this activity was to determine the agroeconomic potential of incorporating organic amendments (OAs) as a partial N substitute within broadacre, dryland cropping and fodder production. Animal derived OAs (chicken litter, composted or fresh layer or feedlot manure) and urban derived composts (UDC) were applied in tandem with full or reduced rates of conventional fertilisers (Urea) to assess plant available nitrogen (PAN), plant-N uptake, and the storage of soil-N, to determine whether OAs have a positive effect on crop yield. This research was conducted in South-East Queensland (SEQ), Darling Downs, Maranoa, Wagga Wagga, Gelong and Strathalbyn regions.

Treatments were applied annually to the same plots for up to 4 years depending on seasonal conditions. OA's were applied using spreading equipment available at the farm (e.g. Djuan, Roma, Langhorn Creek) or brought on to farm by commercial contractors (e.g. Freshwater Creek, Goovigen). All field trial and demonstration sites except for Mulgowie and Felton were large-scale trials with plot sizes that suited use of farm machinery (manure/fertiliser spreader, planting and harvesting equipment).

Additional experiments on the Darling Downs utilised labelled 15N fertiliser with OAs to measure how PAN is influenced by 1) soils of varying clay percentages, 2) application method, i.e., surface applied or incorporating into topsoil, and 3) any residual long-term effects the OA + fertiliser treatments have of subsequent crop yields. COVID limited access to some of the field sites so Mulgowie, Felton and Djuan finished in 2020. Severe drought in 2018-19 also limited crop growth at some of the dryland site, with the Roma site not being planted to a winter Oats crop until 2020. Other sites were established at Wagga Wagga and Biloela (QLD) with limited results due to the dry conditions.

Automated greenhouse gas chambers were installed at Mulgowie and Felton to assess the N2O reduction potential of OAs and effect on soil health.</td></tr>
<tr><td>When did you do it?</td><td>Mulgowie – 2018-2019 Broccoli-Sweetcorn
Felton – 2019-2021 – Wheat-Mungbeans-Fallow-Sorghum
Freshwater Creek – 2020-2023 – Wheat-Wheat-Canola-Wheat
Langhorne Creek – 2019-2020 - Barley
Roma – 2020-2022 – Oats, Oats, Oats (for hay)</td></tr>
</table>

	Wagga Wagga – 2021 – Oats (for hay) Goovigen – 2021-22 – 7 cuts of lucerne / mixed species
Who participated?	University of Queensland Queensland University of Technology Scott Brown (dairy farmer Djuan) Andrew Johanson (manager at Mulgowie) Jason Gillespie (grain farmer at Felton) Simon Faulkner (grain farmer at Freshwater Creek) Peter and Mike Wadewitz (composter and grain farmer at Langhorn Creek) Craig Miller (local agronomist and farmer at Roma) Matt & Justine McLeod (hay and beef farmers at Goovigen)
Who will delivered the activity?	QUT ran the trials in collaboration with University of Queensland on farmer own plots. OA's were supplied from local distributors in each region.
What was the output? How did this contribute to Program objectives listed in the WorkPlan?	Data collected at the sites provided OA analysis (project activity 1 & 2) and OA calculator in activity 6. Yield data, soil nitrogen surplus data collected and used to calibrate OA app and soil health outcomes. Communication materials (fliers, farmer press articles, Stakeholder Powerpoint presentations, field walk demonstrations, field days, conference presentations, journal papers for extension and research purposes
What evidence can you provide? (e.g photographs ?	**Examples of yield and soil nitrogen data from selected sites are shown below. All data has been synthesised into the metadata analysis in chapter 6.**  **Figure 5.1. Effect of Nitrogen fertiliser addition showing a mixed response to grain yield at the Felton field site for the 4 experiments (2019-2021)**

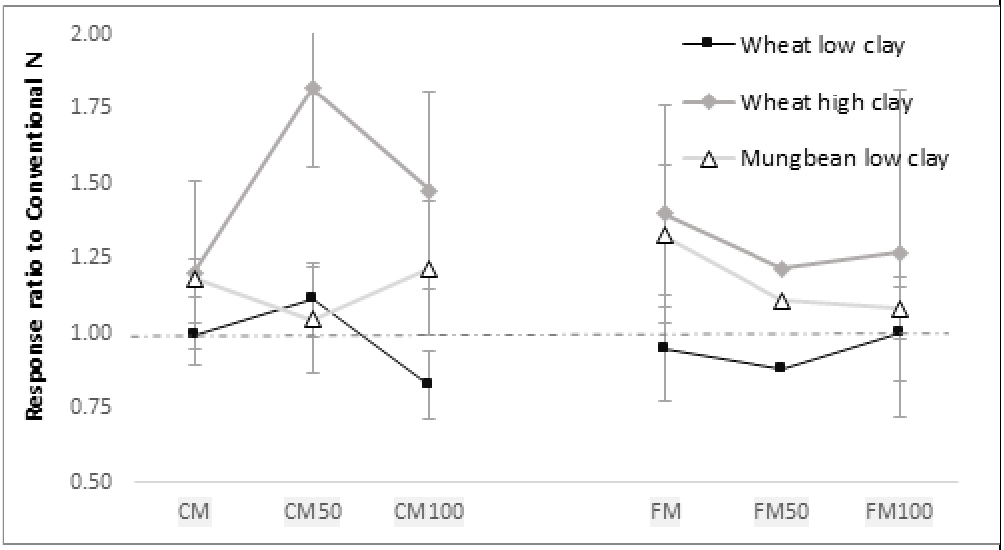


Figure 5.2. Effect of Chicken manure (CM) and Feedlot manure (FM), and combination with urea nitrogen on grain yield at the Felton field experiments (2019-2021)

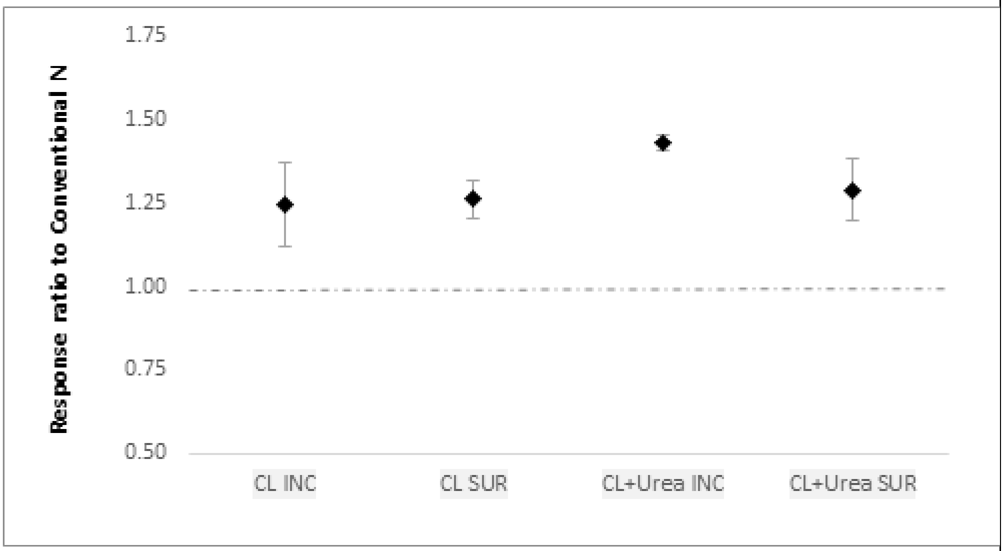


Figure 5.3. Difference in Sorghum yield response to OA incorporation (INC) vs surface (SUR) application for Chicken Litter at Felton. Incorporation significantly increased yields compared to surface application.

5.4) Chief Investigator Daniele de Rosa installing automated greenhouse gas chambers in Broccoli at Mulgowie

5.5) Automated chamber in wheat stubble at Felton

5.6) MSc student Gabrielle Torrisi hand incorporating OA at Felton

5.7) PhD student Ben Vickery applying 15N labelled fertiliser at Felton

5.8) Chief investigators Porter, Rowlings and Biala inspecting a pile of compost ready for spreading at Freshwater Creek

5.9) Calibrating a truck spreader at Freshwater Creek

5.10) Chief Investigator Biala collecting wheat yields at Langhorn Creek

5.11) Freshly harvested wheat plot (1 m2) at Langhorn Creek for yield

5.12) Calibrating Dairy manure using a farmer owned spreader at Djuan

5.13) Principal Investigator Rowlings harvest forage sorghum at Djuan

5.14) Calibrating a farmer owned spreader at Roma fodder trial site.

5.15) Collecting soil samples for analysis at Felton

<table>
<tr><td colspan="2">Project Activity 6 (as listed in your WorkPlan)

Nutrient release curve calculator/phone application from various organic amendments and soil types (Queensland University of Technology).</td></tr>
<tr><td>What did you do?</td><td>Data from Activities 2-5 was collected into a database.
Laboratory incubation tests for nitrogen release or immobilisation from different OA products were conducted at the QUT laboratories. A total of 28 different trials have examined the effect of OA type, application rate, soil type, water content and temperature on the release and accumulation of inorganic nitrogen (N) over 100 days</td></tr>
<tr><td>How did you do it?</td><td>The release of inorganic N (NO_3-+ NH_4+), or mineralisation rate (MR) from these products was calculated over 7, 14, 28, 56 and 100 days, representing the short-medium term release of N under field conditions. Other possible predictors of the mineralisation rate such as soil respiration (CO_2 evolution – as an indicator of labile Carbon (C), parameters of applied OAs (C:N and P:N ratios, inorganic N, dissolved N and C and various carbon fractions) have been analysed on each product to improve nutrient availability estimations in the OA nutrient calculator.</td></tr>
<tr><td>When did you do it?</td><td>Laboratory testing coincided with field application of OA's in Activities 2-5. After field application, a subsample of the OA's were immediately refrigerated and posted to QUT. Incubations ran for up to 100 days.</td></tr>
<tr><td>Who participated?</td><td>All consortium members running field trials contributed OA's for both commercial analysis and nutrient release incubations at QUT.</td></tr>
<tr><td>Who will delivered the activity?</td><td>Incubations were done by QUT. Commercial lab analysis was done by EAL, Lismore</td></tr>
<tr><td>What was the output?
How did this contribute to Program objectives listed in the WorkPlan?</td><td>Laboratory incubation tests provided the nitrogen release or immobilisation rates from different OA products in contrasting soil textures and environmental conditions.
In addition to the Bayesian Function-on-Scalars Regression Model a range of modelling approaches have also been tested. The most appropriate model for N mineralisation for each group of OA was tested against a constant annual mineralisation rate (k), a mineralisation rate that increases linearly with rate increasing time after application (N(%)=a + b Days) and asymptotically. Specifically, the asymptotic function tested was the following:
$$Y=a-(a-b)\exp(-cX)$$
where a is maximum or minimum attenable value of Y (plateau), b the intercept and c is proportional to the relative rate of increase or decrease. The constant annual rate model was the simplest of the three, unless a more complex model provided a significant (P>0.05) improvement of adjusted R2 of the fit.</td></tr>
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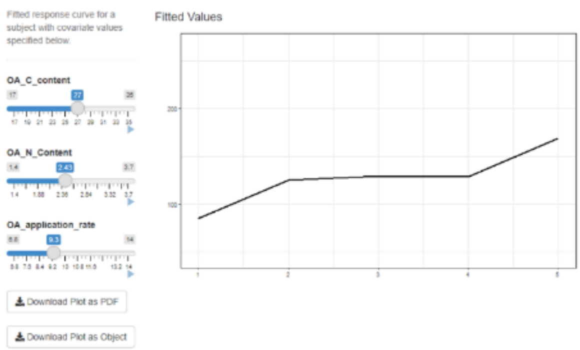

Fig. 1 Graphical user interface for the Bayesian Function-on-Scalars Regression N mineralisation model.

For most OA groups, the asymptotic function provided the best fit amongst the models tested (Fig. 2, P<0.001). The selected models (GAM, Bayesian Function-on-Scalars Regression Model, and asymptotic function) were tested against soil incubation results and field observations.

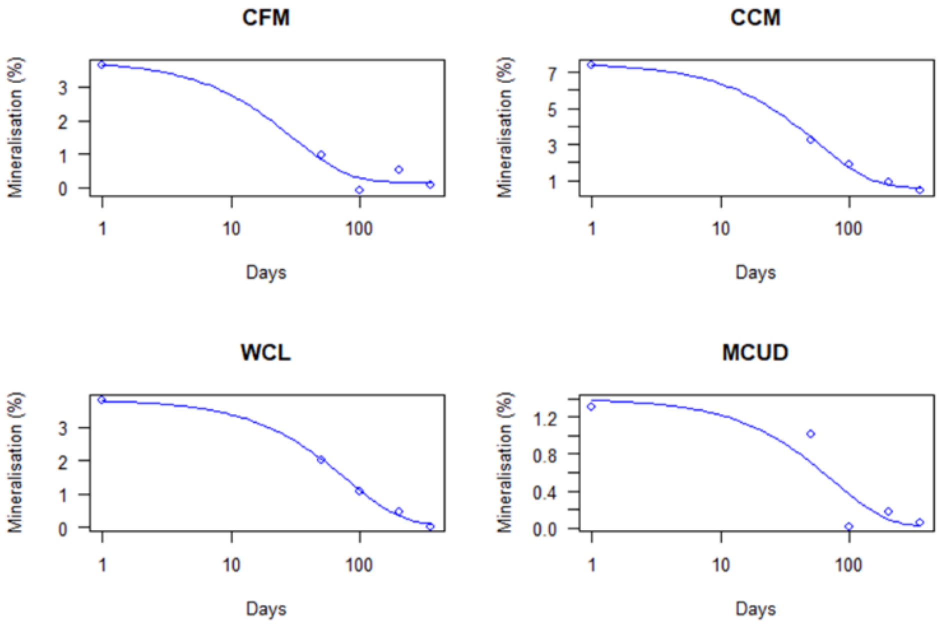

Fig. 2 The asymptotic model results. Line represents modelled data, dots observed data.

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What evidence can you provide? (e.g photographs?

</td>
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The Organic Amendment Nutrient Calculator App can be accessed online or as a phone webpage here: https://oa-nutrient-calculator.netlify.app/oa

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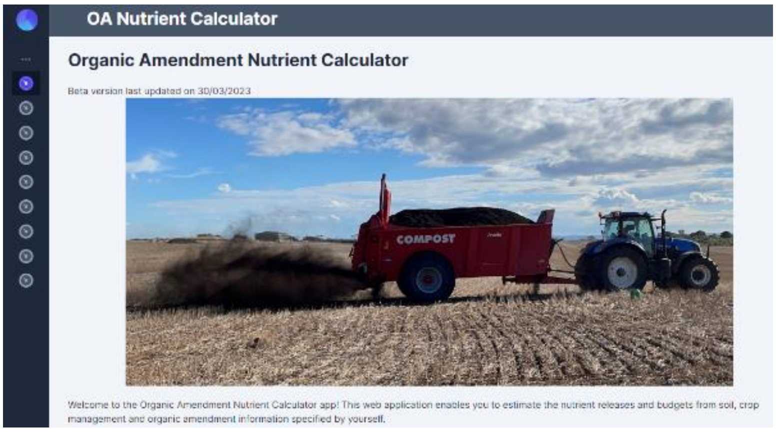
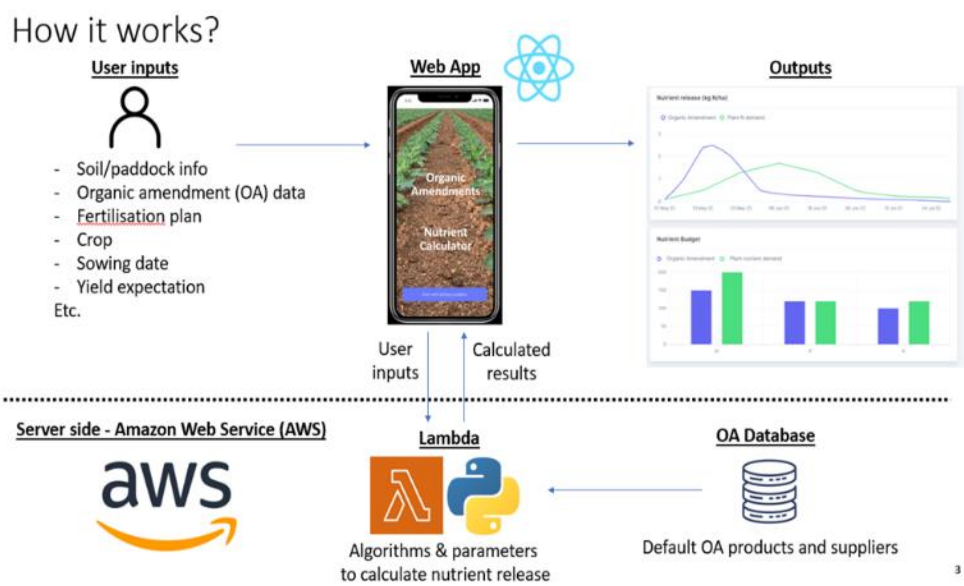


The OA Nutrient Calculator app was demonstrated in the AORA conference 2022.



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Discussion

Use this section to fully describe the results of each outcome and output. Include a description of the Activity overall achievements against the objectives, deliverables and key performance indicators.

Include tables, diagrams or graphs as required.

Integrating organic amendments with mineral fertilizers for comparable or improved crop performance at favourable costs means Australian agriculture can be less dependent on fossil fuel derived urea fertilizer and finite global phosphate resources for crop nutrition and soil fertility. The fact that there are no significant stockpiles of unused manure, compost or other organic residues in the country indicates that all organic amendments are utilized for land management purposes in one way or another. It is estimated that in Queensland alone, some 3M tonne of organic amendments are used annually, which supply around 80,000 of nitrogen, an unknown amount of other macro and micro nutrients and around 1M tonne of carbon to soil. This project raised awareness and helped farmers to recognize and account for nutrient contributions from organic soil amendments, allowing them to reduce mineral fertilizer inputs and realise monetary savings. Essentially, the project asked farmers who use manure or compost anyway, to take advantage of all the benefits they derive from using organic amendments, i.e. to make their farming enterprise more efficient and more profitable.

This project again made very clear and promoted that using OAs needs to move away from a 'waste disposal' mindset to one of nutrient and soil management. This includes the need for farmers to have meaningful analytical test results for OAs they are going to use, as well as the use of appropriate spreading equipment that achieves satisfactory product distribution at the set rate – no different to spreading fertiliser. Without farmers recognising the nutrient value in OAs, upstream attempts of limiting nutrient losses during storage or processing (composting) are futile.

However there are a number of barriers to increased farmer adaptation of OAs. Some, but not all, will be address by the availability of the nutrient calculator, including how much to apply. The application rate of organic amendments should not be determined by choosing an arbitrary number, e.g. 3 or 5 or 10 t/ha, but rather by considering nutrient supply from OAs and crop nutrient demand. This approach works usually best by applying OAs at rates that satisfy crop phosphorus demand, making use of mineral P fertiliser obsolete, certainly over the longer term.

Overall outcomes of Organic Amendment use on yields

The organic amendment database was compiled from all laboratory and field studies undertaken in the project. A metadata analysis was then conducted to tease out the major effects across sites, years and treatments to give an overarching picture of the effect of OA's on biomass yield. Overall adding OAs increase biomass by 8% across all 666 field plots in the project (Figure 1). The effect was larger (15%) when no other fertiliser was applied. No overall difference in yield was discerned between the conventional and optimal rates, meaning nitrogen fertiliser across the project could be successfully reduced by 40% (Figure 2). However there was substantial variation in responses across individual trials so yield penalties are possible in some circumstances.

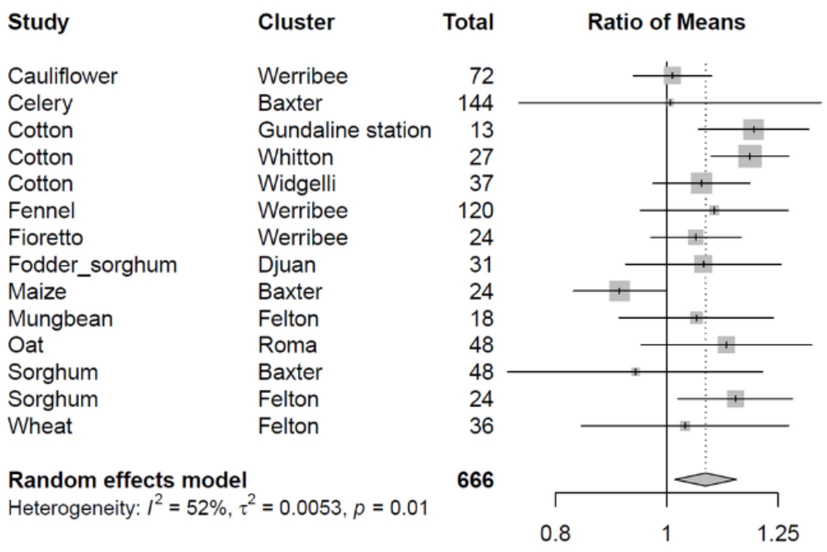


Figure 1. Random effects model of effect of OA application on biomass yields across all trial plots and treatments (n= 666) within the project.

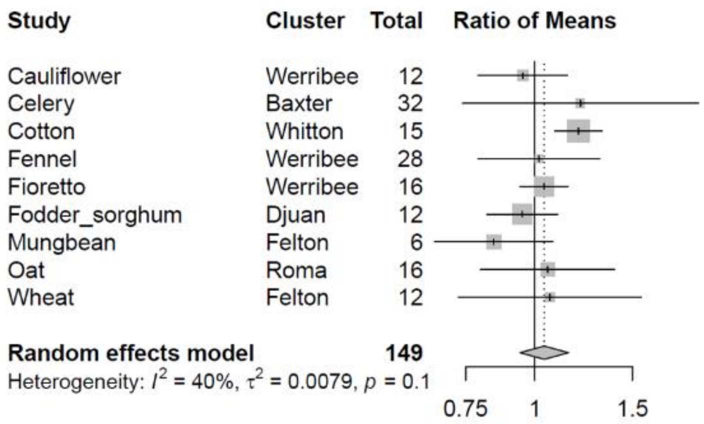


Figure 2. Random effects model of effect of OA application on biomass yields combined with the "Optimal" urea fertiliser rate across all trial plots (n= 149) within the project.

Overall, the medium-term (3 years) effect of multiple annual OA applications on the same plots had a mixed effect on yields, increasing in three in six of the multi-year trials (Figure 3). OAs typically increased yields, with only the urban derived compost or no-additional urea plots in vegetables at Baxter showing a significant yield penalty. Seasonal variability in rainfall, agronomy and crop selection created wide variations in yield response to OAs across all sites.

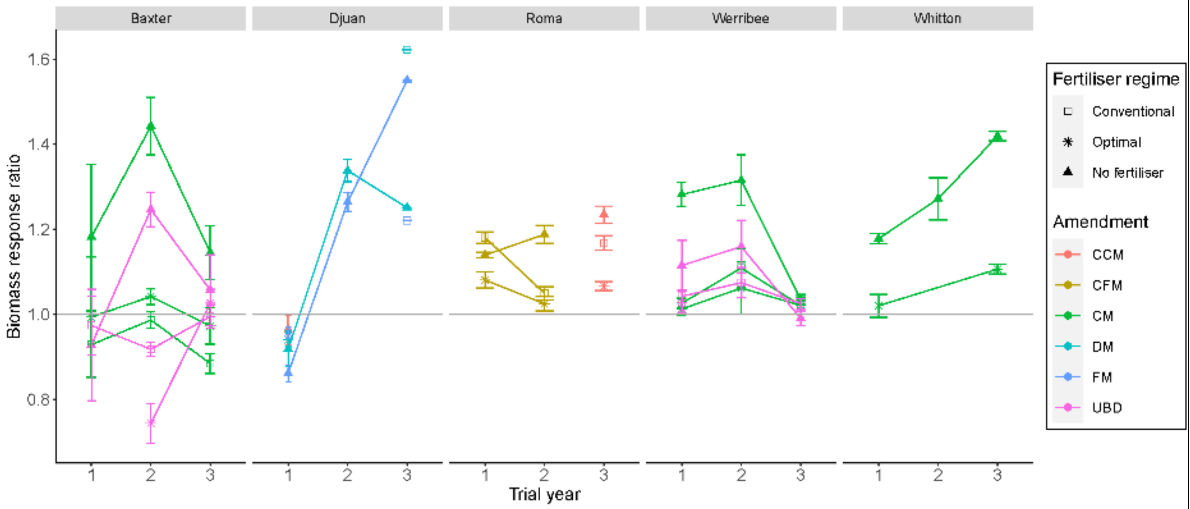


Figure 3. Biomass response ratio with and without OA application across the multi-year trails in the project.

In terms of the drivers of yield impact the combination of OA feedstock (i.e. aged animal manure, fresh animal manure or urban derived), animal (chicken, pig or cattle) and composting had the largest relative impact on yield (Figure 3). This was followed by feedstock X animal, with composted x animal having the least impact. For individual drivers OA feedstock was the most important indicator, while whether the product was composted or not had the least influence.

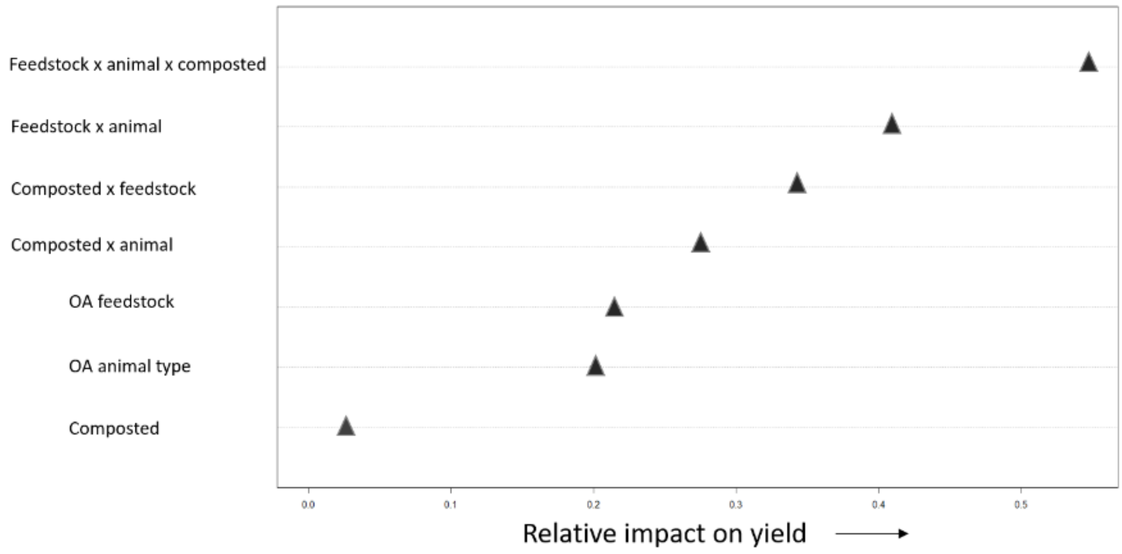


Figure 4. Random forest modeling across all datasets determining which combination of OA traits captures the most variance in biomass response.

Activity 2: Generating a national organic amendment database

Over the course of the project, 65 different organic amendment products were used with each being sent to EAL Lismore for analysis of total and available macro, micronutrients and basic properties. This was combined with product bulk density at time of field application where possible. This data was collated and compiled into a publicly available dataset which can be downloaded from https://oa-nutrient-calculator.netlify.app/resources. Organic amendments were characterised into four groups: chicken litters (CL), chicken manures (CM), feedlot manures (FM) and urban derived wastes (UDC). OAs were characterised as either raw (manure only) or composted (aerated and mixed with a carbon source).

Macronutrient variability within organic amendments

Urban derived wastes possessed the lowest macronutrient content across all organic amendments. N concentrations were lowest in urban derived wastes at an average of 1.58% N (Figure 5), and highest in the chicken manures, at approximately 3.5% N. Feedlot manures possessed an average N content of 2.17%. Chicken litters and manures were not significantly different in N%, with litters only containing a slightly lower average N concentration at 2.9%. No one product was highest across all macronutrients, however each OA was highest in N, K, P and then S, respectively. Feedlot manures had the highest content of K, at an average of 3.4%, and despite sharing similar composition, urban derived wastes were lowest in K at 1.01%. Sulphur was lowest across all OAs except feedlot manures, with an unusually high concentration of 2.5%.

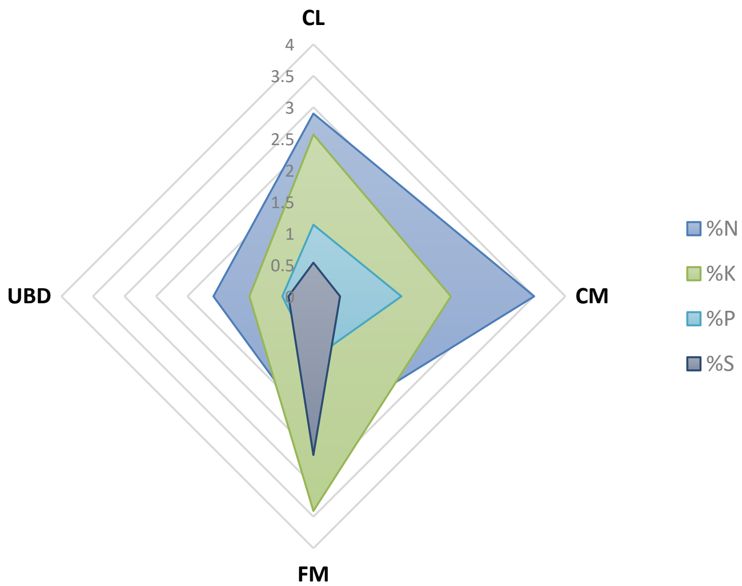


Figure 5. Radar chart displaying major macronutrients concentrations (%) across 4 types of OAs. Values retrieved from LECO elemental analyser.

Carbon was fractionated into both biologically available (organic) and recalcitrant (inorganic) portions, for each OA type. Average total C content ranged between 23 – 30 %, with high degrees of variability across all organic amendments (Figure 6). Feedlot manures and urban wastes were closely related in percent C, averaging 25% and 23%, respectively. Poultry OAs were significantly higher in carbon content, ranging between 30-31% in litters and manures. Inorganic C was lowest in feedlot manures (3% inorganic C). Majority of carbon was encapsulated within organic form as outlined in Figure 3, with 20% or more of the total C being identified as unavailable to plants across all OAs.

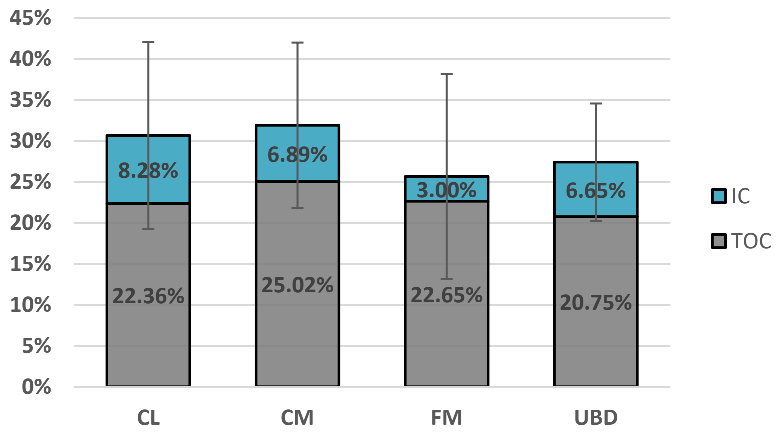


Figure 6. Stacked bar graph displaying portion of total C (%) split into inorganic (IC) and organic carbon (TOC). Values retrieved from LECO elemental analyser.

Nitrogen content was also fractionated into two forms of labile N, NO_3^- and NH_4^+, as well as organic N. Total N was more variable across OA types in comparison to carbon content, varying significantly between each OA (Figure 7). Approximately 90% or more of the N in each OA was in organic form, with a small portion in plant available form, majority of which was NH_4^+

One of the biggest challenges for incorporating OAs into farm nutrient budgets is the imbalance between major nutrients ratios and crop requirements. Carbon to Nitrogen ratios provide a broad indication of nitrogen release in the soil. CN ratios <12, such as found in the chicken litter and manure, typically realise N into the soil once applied, whereas high CN ratios such as the >15 in Urban Derived compost will immobilise N in the soil (Figure 8). Little difference occurred in the N to P ratio of the chicken products and feedlot manure ranging from 2.58 in the FM to 3.72 in the UBD, well above the 8:1 recommended for most crops. As such applying these products at the rate required to meet most plant N requirements would lead to excess P in the profile.

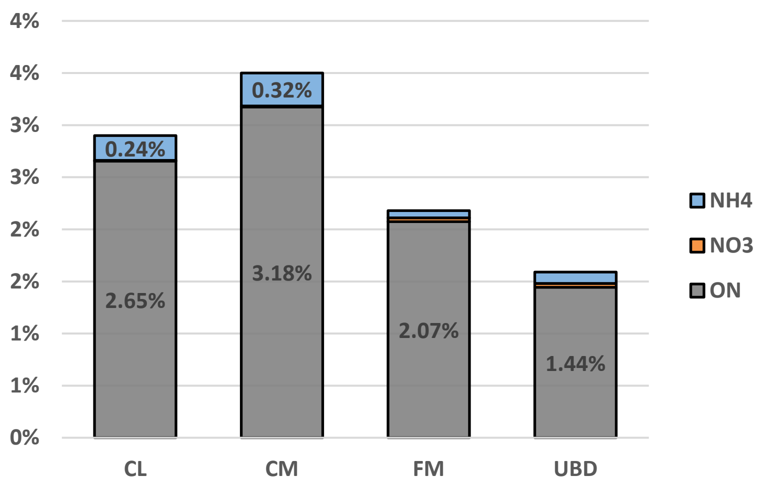


Figure 7. Stacked bar graph displaying total N (%) content in 4 OAs, split into PAN (NH_4 and NO_3), as well as organic N (ON). Values retrieved from Gallery™

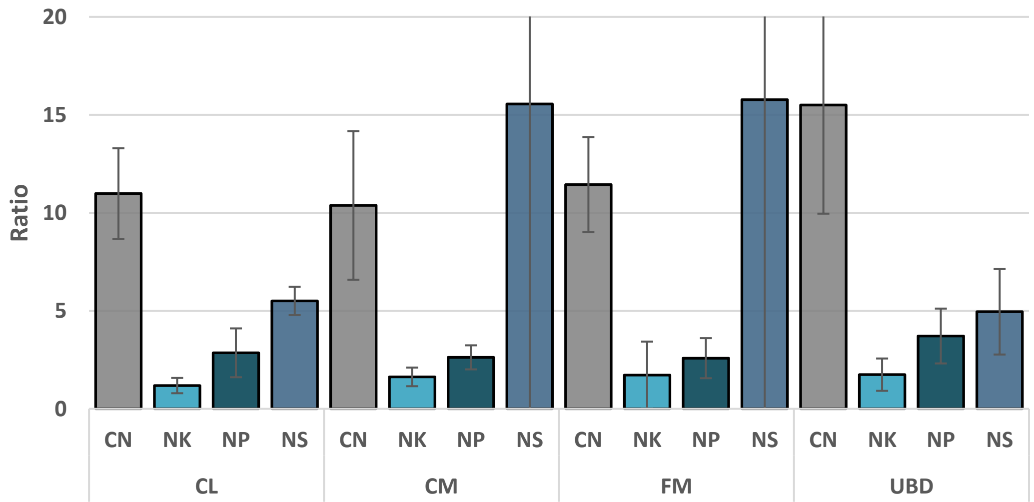


Figure 8. Bar graph displaying average nutrient ratios across 4 OA categories

Micronutrient availability

Organic amendments were analysed against each other for significant variation for each micronutrient (Figure 9). Initial analysis upon the dataset did not demonstrate an overly large variability among the micronutrients analysed. Chicken manures and feedlot manures were not significantly different across any micronutrient sampled, however significant differences were most common between feedlot manures and chicken litters. Chicken litters and chicken manures did not vary considerably despite great variation in composition and age within this dataset.

When average micronutrient content was scaled up to large scale agricultural application values (kg per tonne of product), differences in micronutrient availability were highlighted. Of the critical micronutrients, FM contained the most total zinc (0.56 kg/t) and silicon (1.45 kg/t), while CL had the highest boron (0.05 kg/t) and molybdenum (0.13 kg/t). Magnesium was highest in concentration across all amendments, varying between 5.5-9.5 kg/tonne compared to less available micronutrients such as selenium (Se) which supplied an average of 0.001-0.002 kg/tonne, with a 0.001 kg/tonne variation.

Nitrogen release from OAs

To determine the percentage N mineralised 20 different organic amendments were tested in a long-term aerobic incubations. Organic amendments were mixed with either clay or sandy soil, the treated soil will be packed into PVC cores (15cm height, 4.42cm diameter) to bulk density of $1 g/cm^3$. Organic amendments were added at the rate of 15 t/ha for composted materials, and 7.5 t/ha for raw products. Inorganic N (NO_3^- + NH_4^+) release was measured on four core replicates sampled destructively at 0,7,14,28,56 and 100 d after incubation at constant temperature (28 °C) and water (80% field capacity). For the OA groups tested, the asymptotic function provided the best fit amongst the models tested (Figure 10, $P<0.001$). The selected models (GAM, Bayesian Function-on-Scalars Regression Model, and asymptotic function) form the basis of the nutrient calculator soil nitrogen predictions.

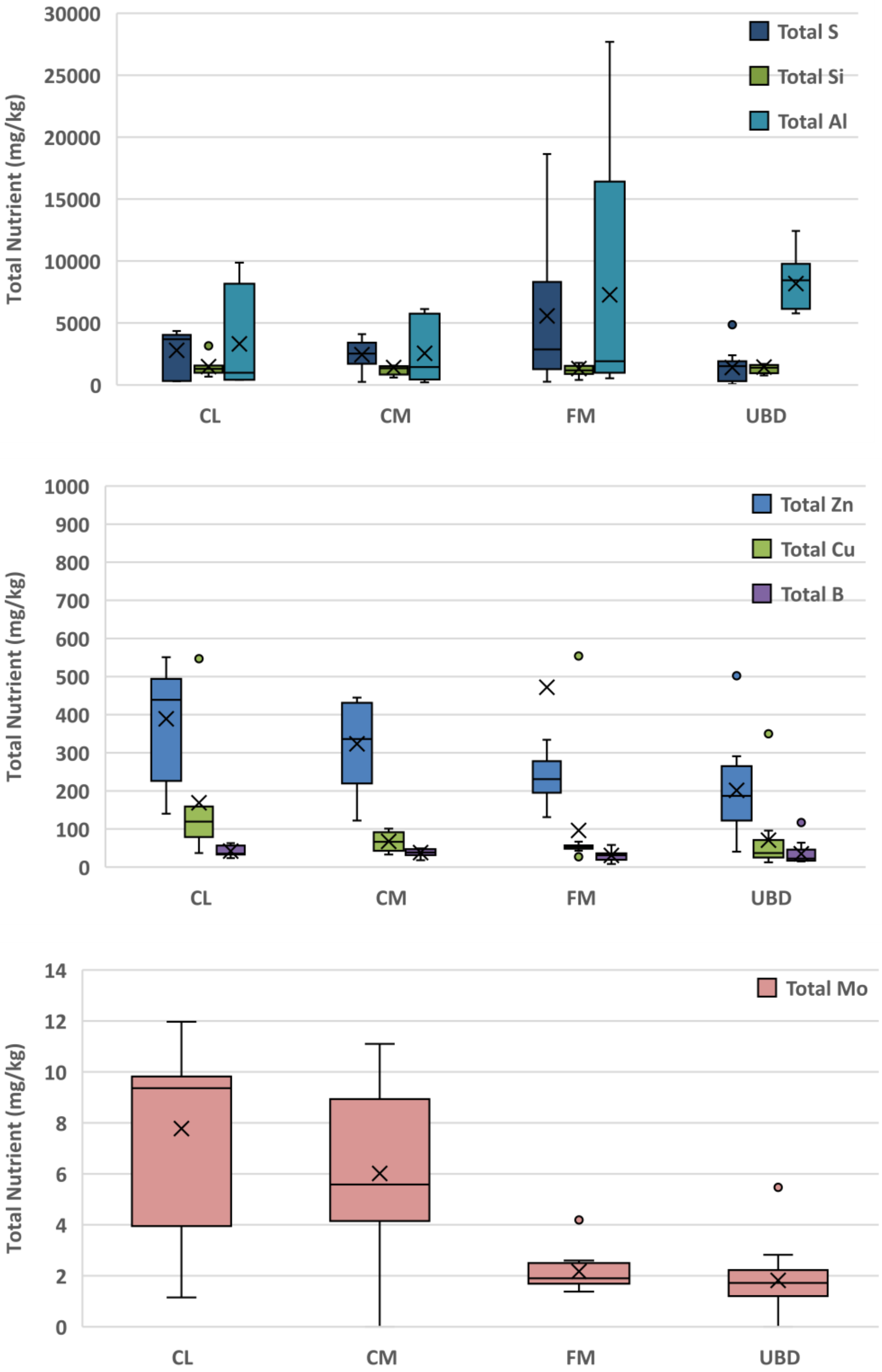


Figure 9. Micronutrient content of the four groups of Organic Amendments.

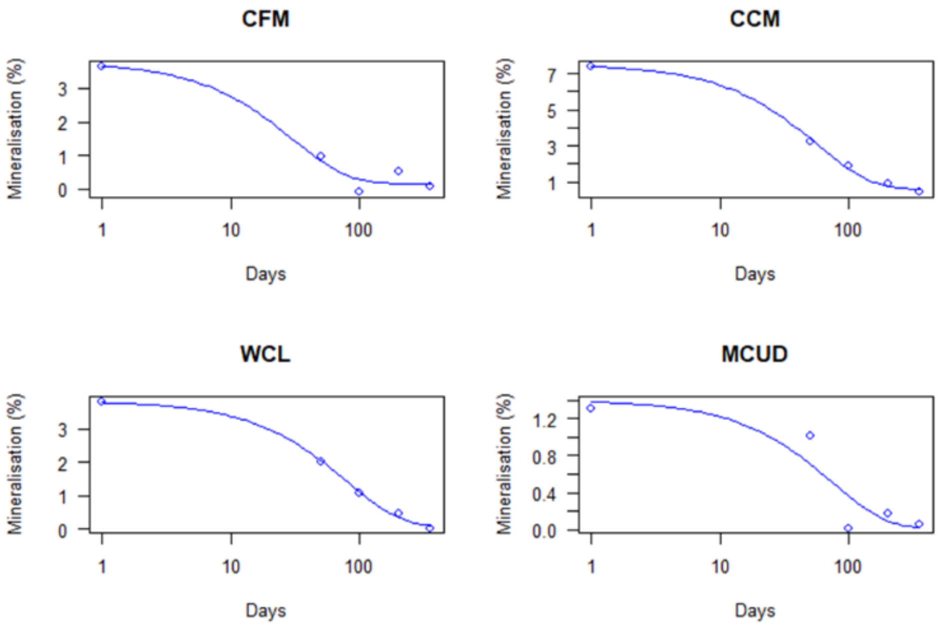


Figure 10. The asymptotic model results. Line represents modelled data, dots observed data.

Activity 3: Organic Amendment trails in irrigated cotton

This project activity assessed the capacity of poultry manures to reduce nitrogen inputs or increase yields in cotton in the Riverina irrigation area of NSW. Trails were conducted over four sites, with eight site-years of data collected. The volumes of poultry litter produced in the Riverina, availability, characterization and application rate effects on irrigated soil and crop performance have been described and demonstrated on-farm at commercial scale. The project has provided information that will allow farmers to use these wastes more strategically and with predictability within crop nutrient budgets to offset and augment traditional N and P mineral fertilizers and for soil sustainability.

Cotton yield increased with annual poultry litter application on a red brown earth soil type: Over 3 years of consecutive application of integrated urea-N/poultry litter fertilization compared with urea-N only, there was cumulatively 2.1-3.8 bales/ha more cotton fibre (Figure 11). This equates to a potential increase in income of $2000/ha over three years.

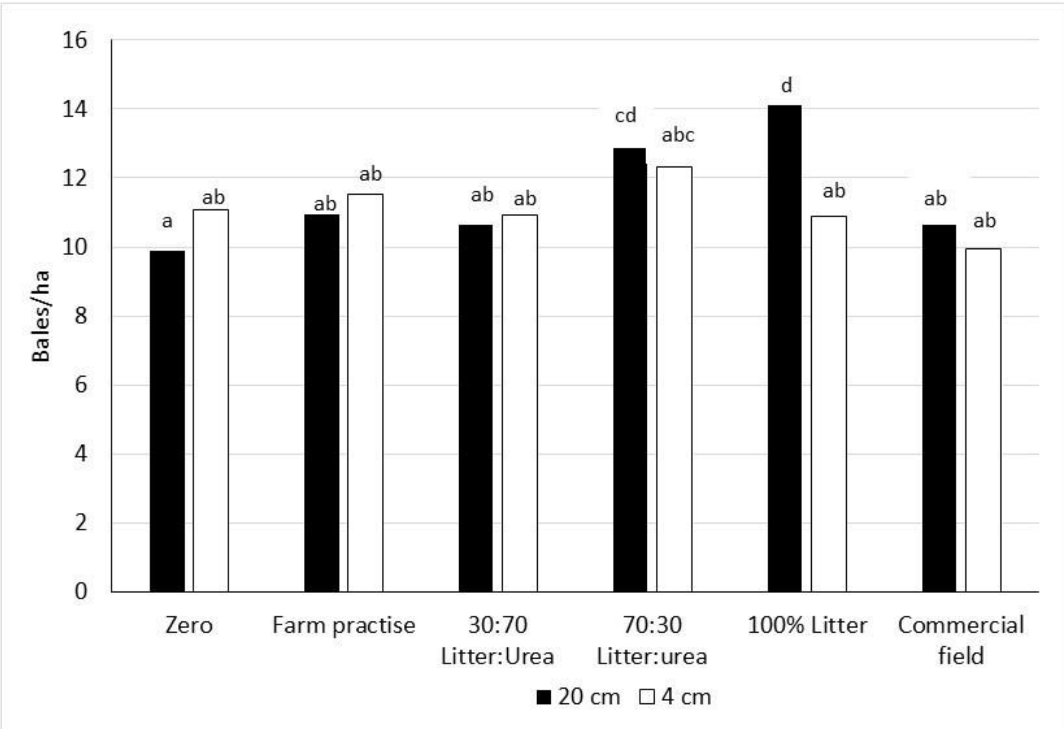


Figure 11. Cotton lint yield, Widgelli, 2018-2019. Target N rate was 280 kg N/ha. Farm practise comprised urea-N only. Other treatments were proportions of Litter-N:Urea-N. Application rates of litter were based on moisture content, total nitrogen (%), mineral-N content and using a 1st year available N factor of 0.55.

Application of poultry litter increased both nitrogen (Figure 12) and phosphorus availability to the cotton crops across all trials. In a red/grey clay vertosol, a maximum of only 33% of applied urea-N was utilized by the in- season crop with large amounts retained in surface soil when integrated with poultry litter. The litter may preserve co-applied urea- N which could be available for use by subsequent rotational crops and this could be a consideration for medium term crop management. Poultry litter increased uptake of soil N by cotton but did not improve urea-N plant uptake in integrated applications. Integrated mineral:organic fertilizer programmes are required to fertilize not only the plants directly but also for soil fertility so that soil nutrient recycling and plant supply are maximized and mineral fertilizer applications are reduced.

Potential saving in fertilizer costs were calculated for each trial. Each tonne of poultry litter, readily available from broiler sheds in the Riverina typically contains 15 kg of available N and 8 kg of available P. This has enabled cotton growers to reduce their fertilizer rates by 80 kg urea-N/ha and completely replace mineral phosphorus at practical spreader application rates. Our calculations show a potential saving of a typical annual fertilizer programme of approximately $80/ha.

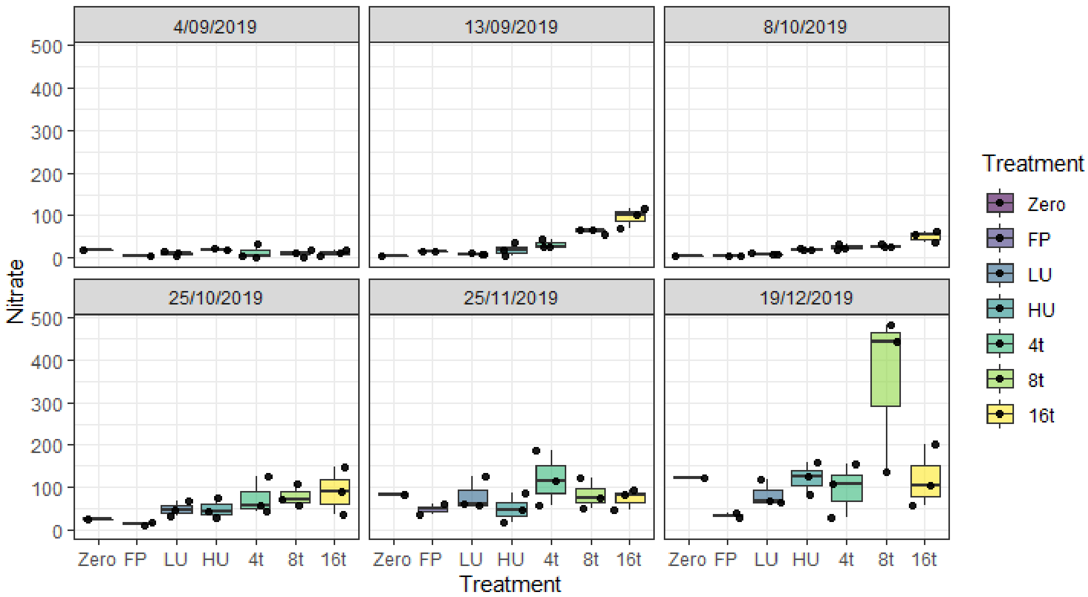


Figure 12. Nitrate concentrations in soils amended with different rates of chicken litter compared with a urea only fertilizer treatments. Pre-trial - 4/9/19, 13/9/2019 – litter applied and thereafter to 19/12/19.

Activity 4: High-value horticulture

On-farm demonstration trials conducted over longer periods (i.e., 3 years in this project) are highly visible and generate considerable interest within industry, and therefore can influence change and grower adoption. For example, following a key webinar about the medium-term trials in this project, 94% of vegetable grower attendees reported increased awareness of how to better manage OA and synthetic fertilizers and 68% said they would change an aspect of their farm-management based on the information and results they received. Organic amendment use by the high-value horticulture industry is frequently aimed at non-nutrient applications such as mulch, surface protection and soil health. Therefore increasing grower awareness of how to account for OA nutrients, the cost savings and environmental benefits can have a large impact on Australia's agricultural sustainability.

Trials conducted in high-value horticulture confirmed that organic amendments (OA) are a valuable source of nutrients for early crop production. However almost all trials demonstrated OAs alone cannot adequately supply crop nutrients and supplementation with synthetic urea is still necessary (Figures 13 to 15). The incorporation of composted chicken manure did significantly increased nitrate-N concentrations in soil soon after application, and improved crop yields by up to 50% compared with the untreated control. Yields in the optimised treatments were not significantly reduced from the full rate of nitrogen currently applied by growers. The trials demonstrated how accounting for the nutrient benefit of high-N OA (e.g., chicken manure products) could reduce fertilizer inputs by up to 60% while maintaining yield. This benefit saved growers up to $2,600 /ha in fertilizer costs and improved nitrogen-use efficiency. Understanding the nutrient inputs from OA using the nutrient calculator, and reducing fertilizer inputs accordingly is an important new tool for growers to minimize N-inputs into their cropping systems, and this has the potential to reduce downstream environmental impacts.

Figure 13. Fennel trial displaying nutrient deficiency symptoms in low nutrient treatment.

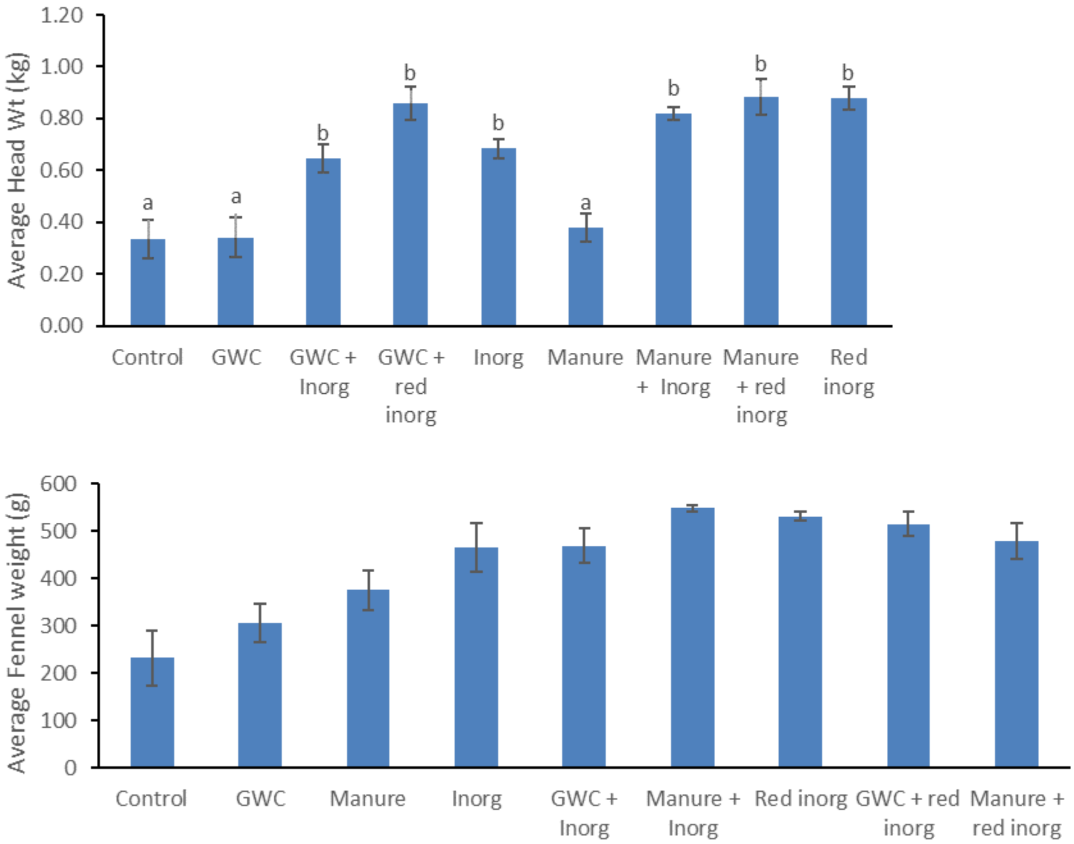


Figure. 14 a) Fioretto yield (average head weight in kg) and b) average Fennel bulb weight (g) for Werribee, Victoria for the winter and summer crops.

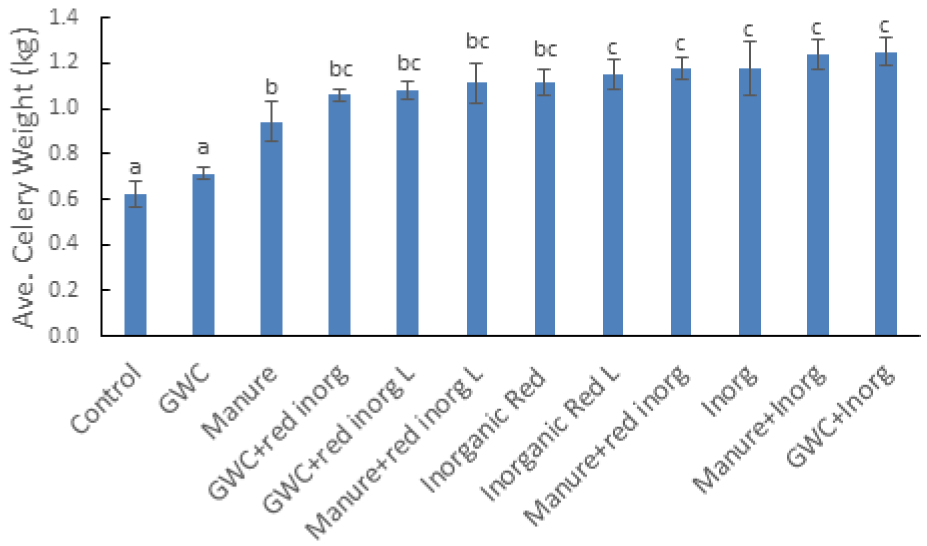


Figure 15. Celery yield, Baxter Victoria, November 2020

These medium-term trials showed that consistent application of OA to soil positively influenced physical aspects of soil health. OAs improved physical properties of soil health (e.g., aggregate stability) by up to 20% after three years of application relative to the use of inorganic fertilizers only. Improvements to soil physical health have been associated with increased water infiltration, gas exchange (less surface crusting) and reduced energy inputs (i.e., fuel) for preparing soils for cropping. However, longer-term trials (i.e., at least 5 years into the same soils) are needed to demonstrate the full benefits of OA on soil health and industry sustainability.

However the use of OA with mineral fertilizers increased emissions of nitrous oxide from soil to the atmosphere by up to 50% across diverse soil-types and production systems, compared with fertilizers alone (Figures 16 to 18). While N_2O was reduced with the optimised fertiliser rate, it was still substantially higher than the inorganic fertiliser treatments only. The carbon added in OA's plays a critical role in soil health and function, but in extremely low/depleted carbon soils such as those frequently cultivated for horticulture carbon can also be the most limiting factor for microbial N_2O production. Uncontrolled, this will have significant impacts on the environment in terms of global warming and stratospheric ozone degradation. Further research and lifecycle analysis are urgently required on ways to minimize and mitigate the release of nitrous oxide from soils treated with OA and inorganic fertilizers, which may include easy-to-adopt solutions such as the application of nitrification inhibitors, slow-release products, organo-mineral fertilizers, and the timing of OA and fertilizer application.

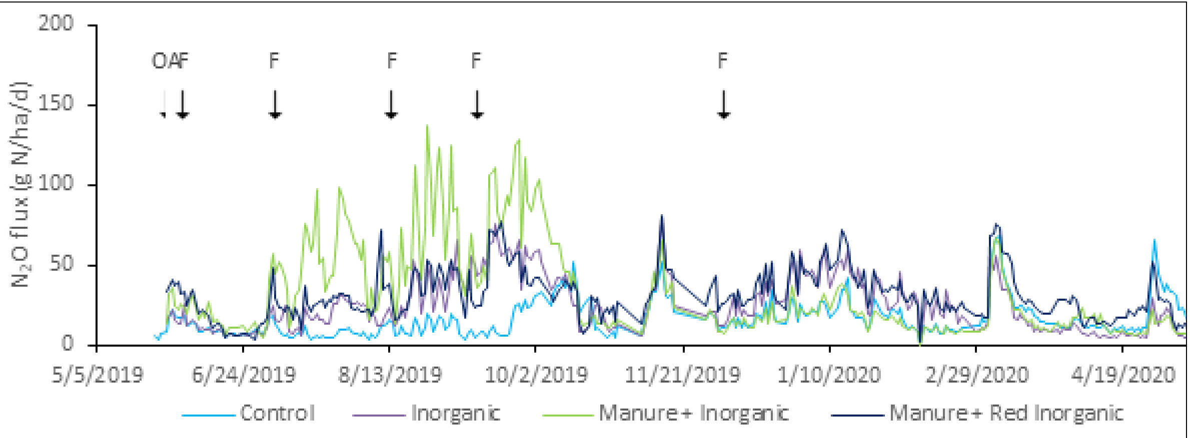


Figure 16, Baxter Year 1 (Celery-maize rotation) N2O emissions. OA=Organic amendment application, F=Fertilizer application

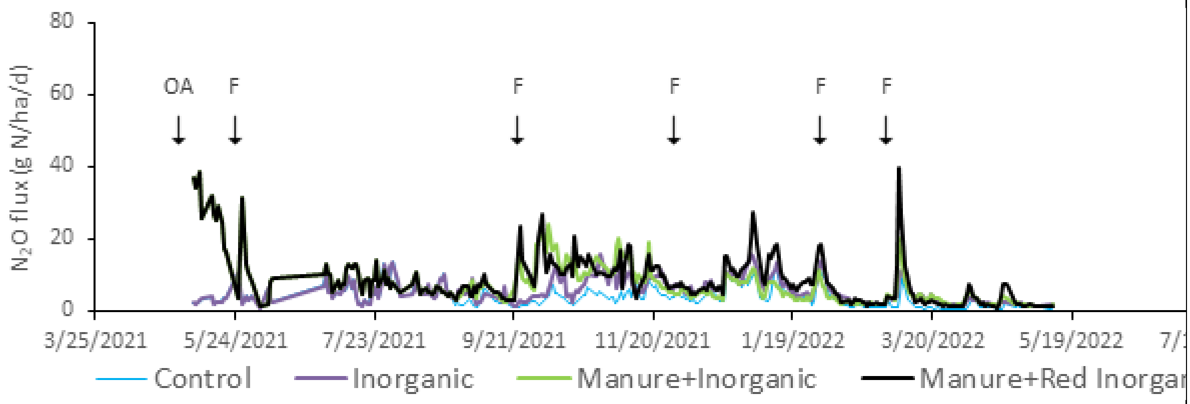


Figure 17. Toolangi Year 1 (Strawberry runners) N_2O emissions. OA=Organic amendment application.

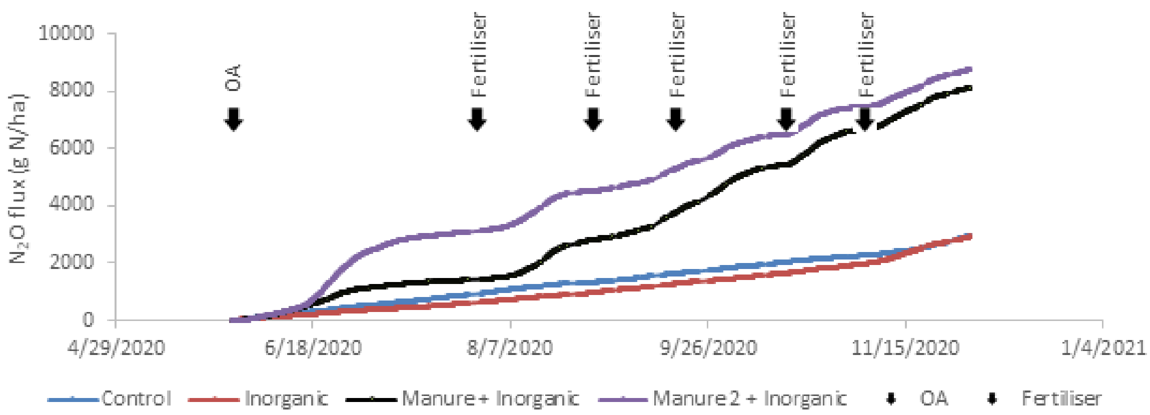


Figure 18. Cumulative emissions for the 2020 Celery season at Baxter showing a significant increase in N_2O emissions associated with OA application.

Activity 5: Dryland cropping

The large-scale field trials in dryland cropping showed that combined use of OAs with reduced mineral fertilizer rates can provide yields that are similar to those obtained with standard mineral fertilizer application rates. In the low input farming system in Roma (oaten hay) where standard and reduced mineral fertiliser use yielded the same amount of biomass, the use of manure based compost (4 – 5 t/ha/yr) increased biomass yield (average over 3 years) by 5% and 14% where reduced and standard fertiliser rates were used, respectively, compared to yields obtained with standard mineral fertiliser alone (Table 1). Areas where only compost was used and no mineral fertiliser yielded as much biomass as was harvested from the conventional rate.

At Felton on the Darling Downs, extremely dry conditions during the trial period of 2018-19 resulted in a mixed response to N fertiliser as pre-plant soil nitrate levels were high and the dry conditions limited yield potentials (Figure 19). While there was a response to OA's of 20-30% above the conventional fertiliser rate in both the wheat (high clay with adequate stored moisture) and following mung-bean crop, there was no consistent interaction with the additional urea fertiliser (Figure 20). The addition of chicken litter to a 2nd sorghum trial at the Felton site increased yields by ~25%. No impact of incorporation was observed with the litter alone, but an additional ~20% yield benefit was measured following incorporation of the conventional urea in combination with the chicken litter (Figure 21). While it's uncertain the exact mechanism for this increase it's possible the incorporation of OA allowed the plants greater access to other nutrients supplied by the amendment as well as ensuring it was accessible to the plant roots for longer.

Table 1. Relative dry matter yield (%, 3yr avg) with various fertiliser – compost combinations in Roma

Stand Fert	No Compost	100.0
	Compost	113.9
Red Fert	No Compost	99.2
	Compost	105.0
Zero Fert	No Compost	84.2
	Compost	100.7

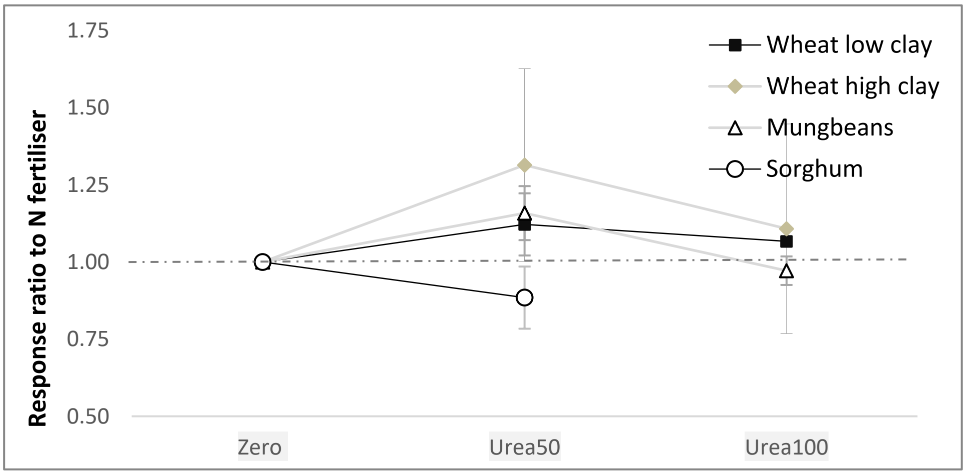


Figure 19. Crop response to added nitrogen fertiliser at Felton, Darling Downs.

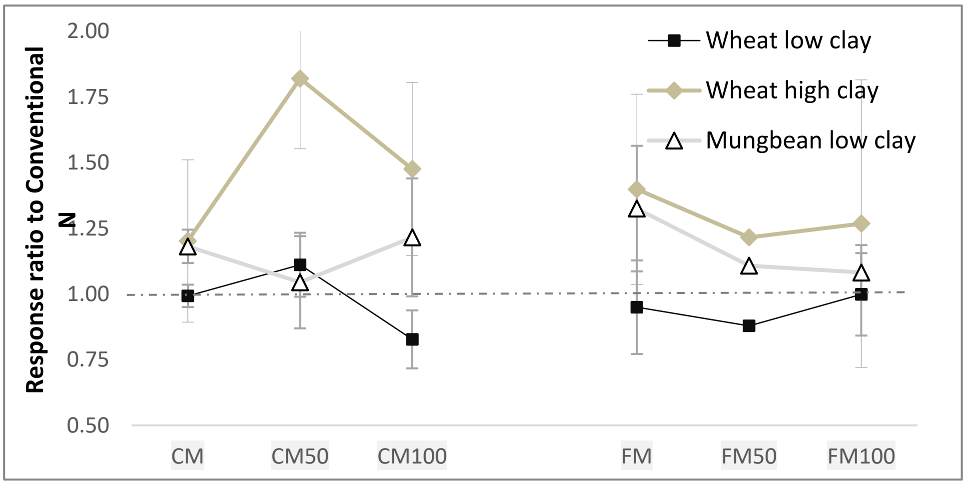


Figure 20. Crop response to the interaction of OA's (CM = Chicken Manure and FM = Feedlot Manure) and added nitrogen fertiliser at Felton, Darling Downs.

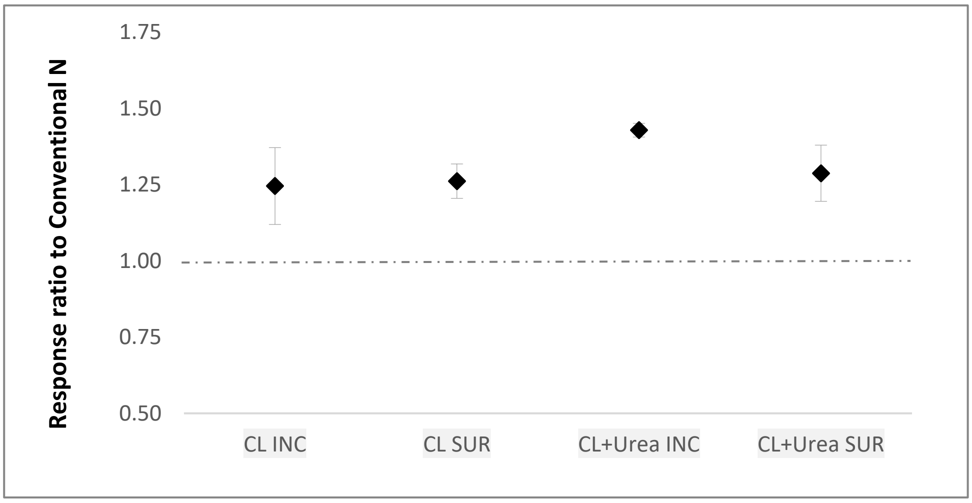


Figure 21. Grain sorghum yield response to chicken litter incorporation vs surface applied compared to the conventional urea application at Felton, Darling Downs.

In the high input farming system in Freshwater Creek (barley hay, wheat, canola, wheat) the reduction in mineral fertiliser rates did not have a discernible effect, as none of the achieved yields were lower than those achieved with standard fertiliser alone (Table 2). The marked yield loss (21.5%) seen where no fertiliser was used, was to a large degree compensated by the use of OAs. Sub-surface applied urban compost provided the best response in combination with both standard and reduced mineral fertiliser, increasing biomass yields by 30% and 20%, respectively above yields achieved with standard fertiliser alone. Use of surface applied chicken litter and composted manure helped to increased biomass yield by around 10% and 15% to 20% where reduced and standard mineral fertiliser rates were used, respectively, compared to standard fertiliser alone.

Table 2. Relative dry matter yield (%, 3yr avg) with various fertiliser – OA combinations in the high-rainfall cropping zone of Freshwater Creek near Geelong, Victoria.

Organic Amendments	**Reduced Fert**	**Zero Fert**	**Standard Fert**
No OA	108.3	78.5	100.0
Manure Compost	110.8	97.2	115.3
Chicken Litter	108.3	103.5	119.7
Urban Compost	101.8	94.2	109.8
Urban Compost - subsoil	120.4	96.6	130.6

Activity 6: Organic amendment Nutrient Calculator

The Organic Amendment (OA) Nutrient Calculator app enables you to estimate the nutrient releases and budgets from soil, crop management and organic amendment information.

The soil properties of your paddock should be specified on the "Soil data" page (Figure 22). Soil properties can be set manually based on your records or retrieved from the national database. Coordinates can be set by clicking the location on the map. "Retrieve the soil data" will get soil properties of the specified location from "Soil and Landscape Grid of Australia (SLGA)". The retrieval of soil properties from the SLGA database are currently set at the 0-5 cm soil depth.

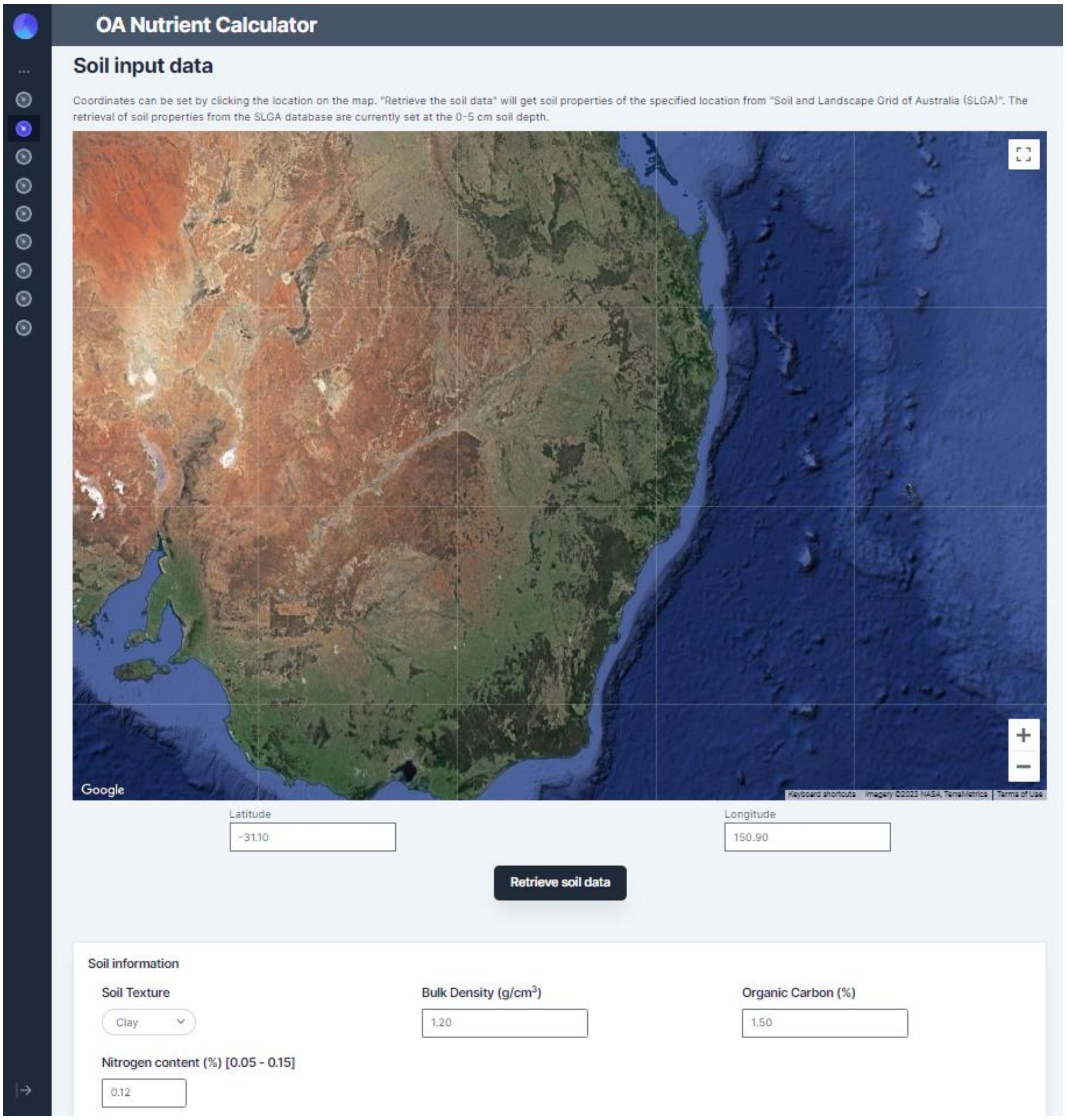


Figure 22. Soil data page to specify the soil properties of your paddock

Then, the crop management assumptions (e.g. crop, sowing date and expected yield) should be configured on the "Crop data" page (Figure 23). Insert expected grain yield for grain crops or aboveground biomass for fodder crops to be exported in the "Expected yield (t/ha)" section. This expected yield is used to estimate the amounts of nutrients to be removed and thus the nutrient budget.

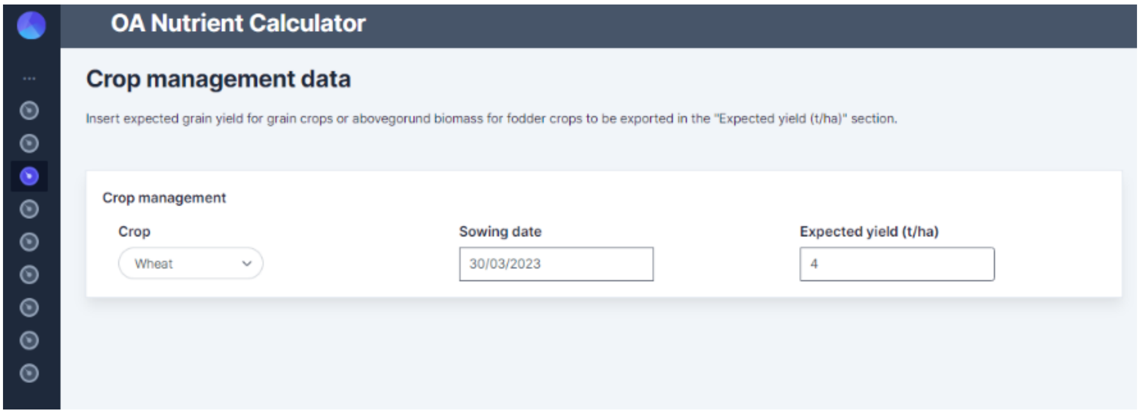


Figure 23. Crop data page to specify the crop management information

The organic amendment product information should be specified on the "OA data" page (Figure 24). A csv file can be uploaded to import the chemical analysis results and set the properties of the OA product. The variable labels need to follow the specific names as in the example csv which can be downloaded below. Each property of the organic amendment product can be specified manually on the page as well.

After specifying the soil, crop and OA information, check out the estimated nutrient release and the nutrient budget on the "Output" page (Figure 25). Currently N release from the OA product and crop N demand are simulated and displayed over the season. The nutrient budgets for N, P and K as well as the supply of other selected nutrients are calculated. This nutrient budget can be added by clicking “Add to comparison and try another plan” button and you can compare multiple plans on the "Compare plans" page by repeating these steps.

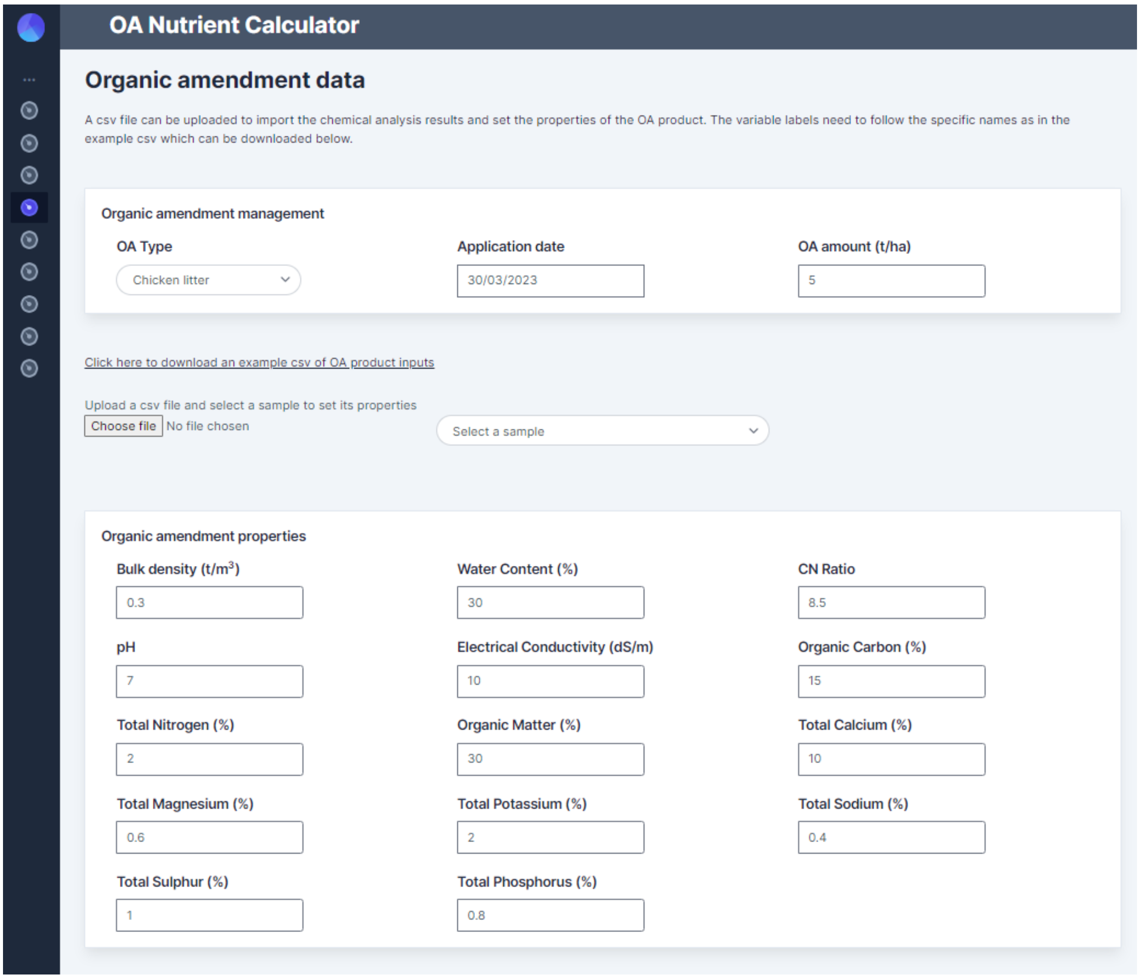


Figure 24. OA data page to specify the OA product information

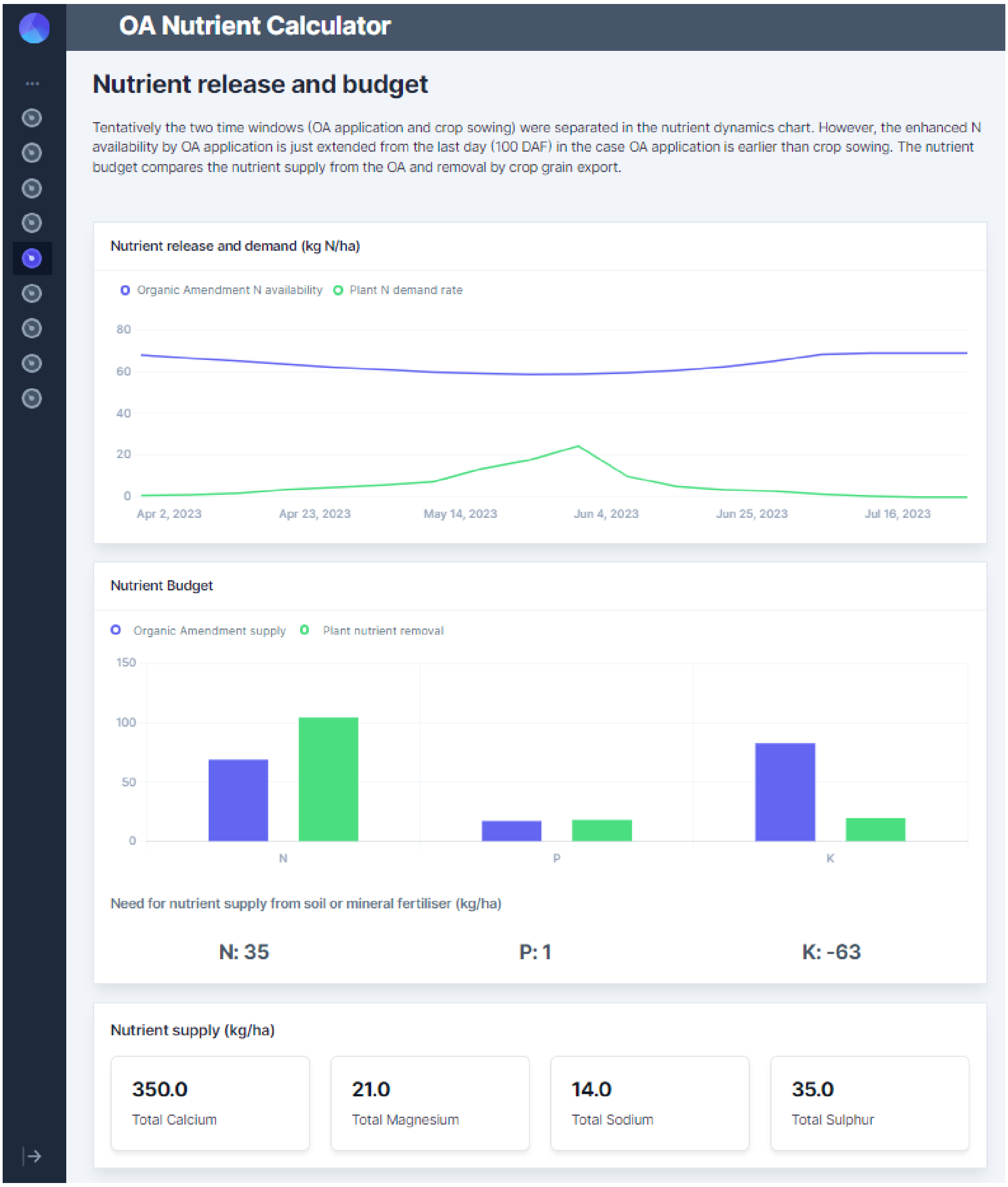


Figure 25. Estimated nutrient release and crop nutrient removal, nutrient budget to NPK and other nutrient supply on the output page

Functions for economic analysis are available on the "Compare prices" page, enabling price comparison between organic amendment and other synthetic fertilisers per unit amount of nutrient (N, P, K) based on user-defined prices (Figure 26). Furthermore, a fertiliser planner function is under development and a test version is available on the "Compare prices" page (Figure 27). This function optimises the combination of OA and synthetic fertilisers to achieve the crop nutrient demand with the minimum cost.

Also, “Resources” and “Acknowledgements” are established so that users can go through the materials used to develop the nutrient release calculation as well as the participants of the projects and their contributions. You can download the OA analysis database as a csv file from the “Resources” page (Figure 28).

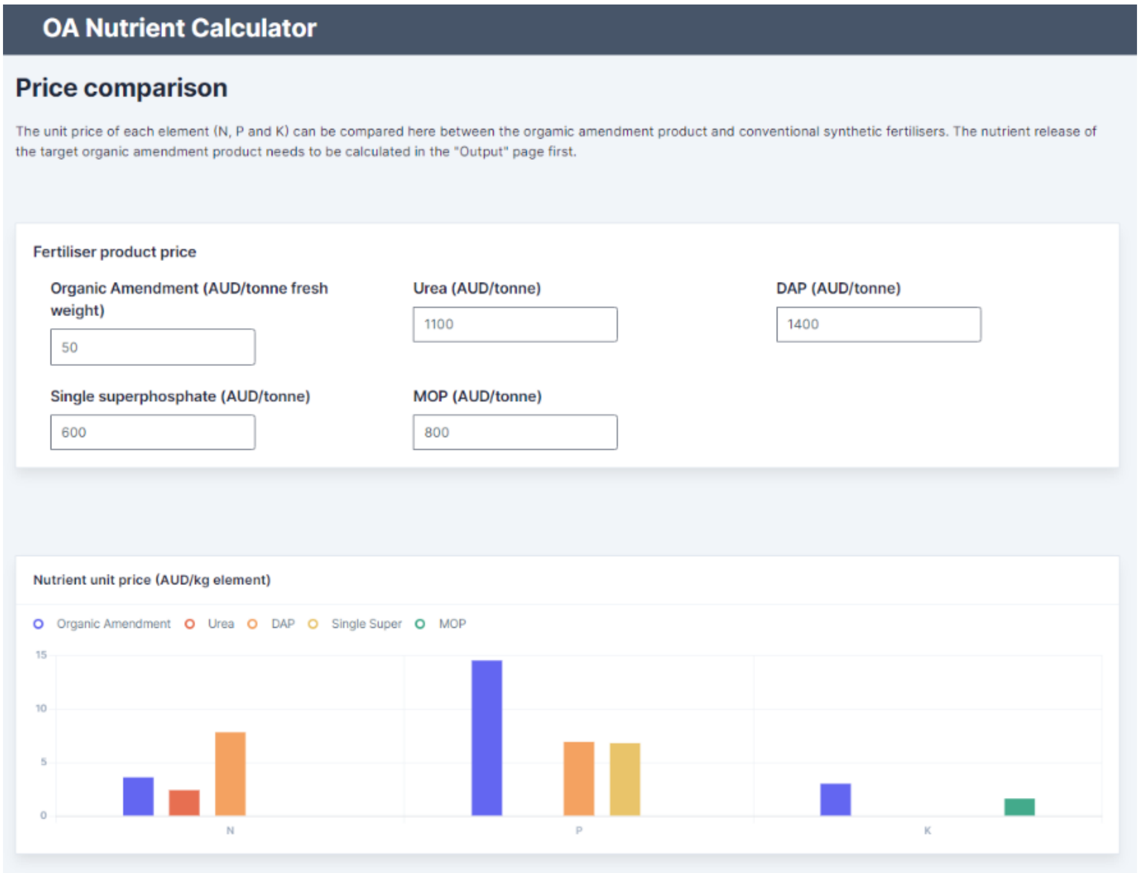
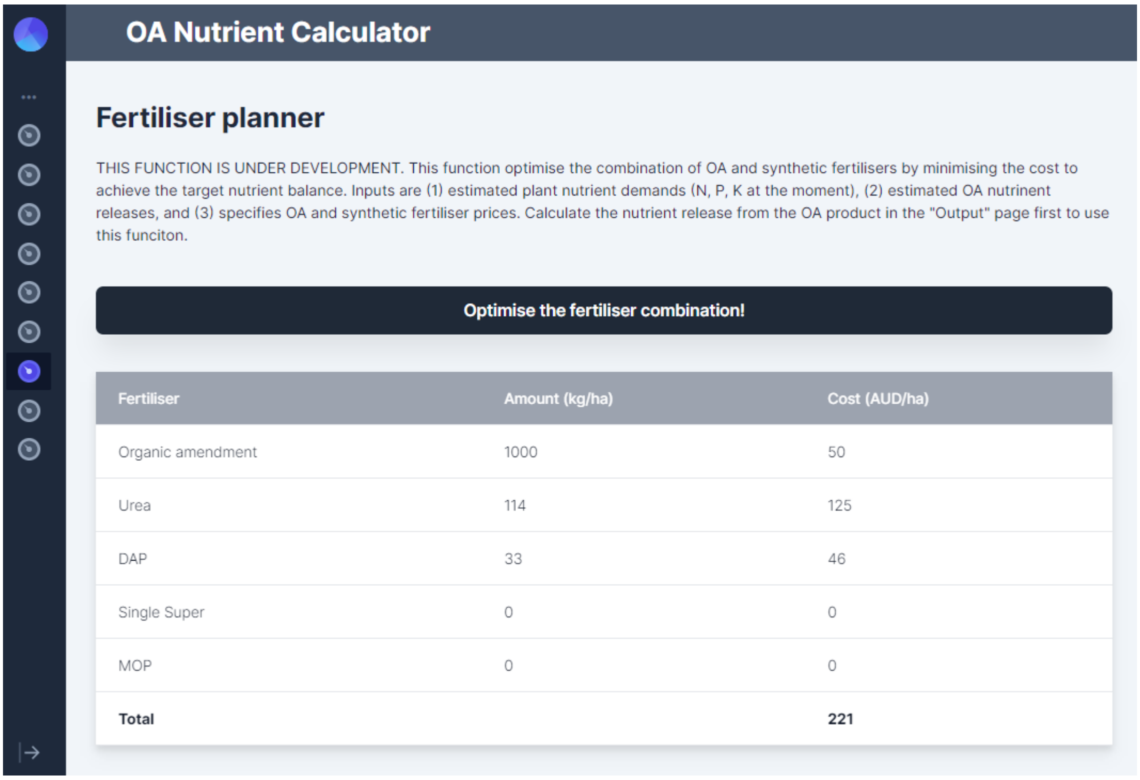


Figure 26. The function to compare prices of OA and synthetic fertilisers



OA Nutrient Calculator

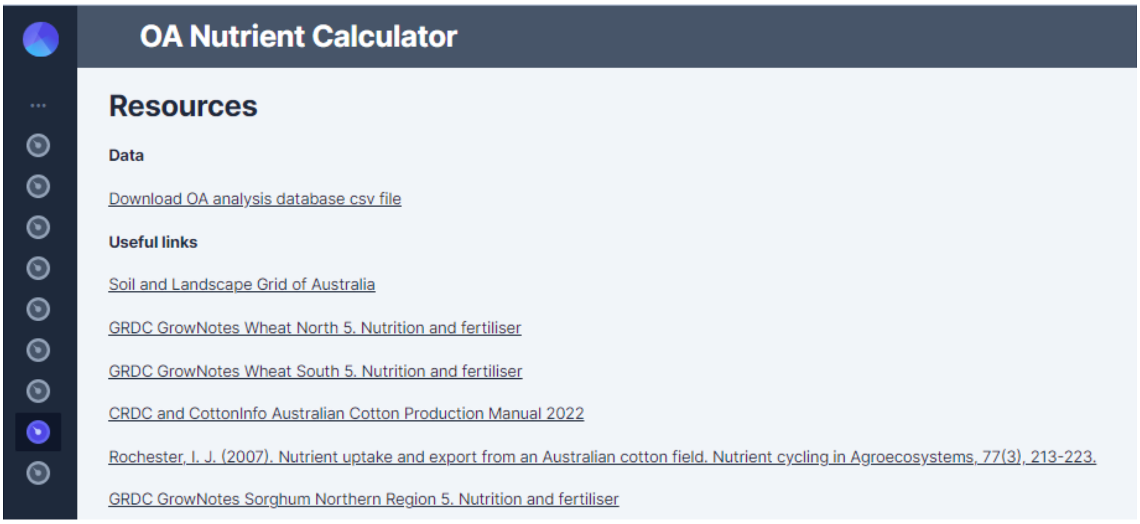
Fertiliser planner

THIS FUNCTION IS UNDER DEVELOPMENT. This function optimise the combination of OA and synthetic fertilisers by minimising the cost to achieve the target nutrient balance. Inputs are (1) estimated plant nutrient demands (N, P, K at the moment), (2) estimated OA nutrient releases, and (3) specifies OA and synthetic fertiliser prices. Calculate the nutrient release from the OA product in the "Output" page first to use this funciton.

Optimise the fertiliser combination!

Fertiliser	Amount (kg/ha)	Cost (AUD/ha)
Organic amendment	1000	50
Urea	114	125
DAP	33	46
Single Super	0	0
MOP	0	0
Total		**221**

Figure 27. A test version of the function to compare prices of organic amendment and synthetic fertilisers



OA Nutrient Calculator

Resources

Data

Download OA analysis database csv file

Useful links

Soil and Landscape Grid of Australia

GRDC GrowNotes Wheat North 5. Nutrition and fertiliser

GRDC GrowNotes Wheat South 5. Nutrition and fertiliser

CRDC and CottonInfo Australian Cotton Production Manual 2022

Rochester, I. J. (2007). Nutrient uptake and export from an Australian cotton field. Nutrient cycling in Agroecosystems, 77(3), 213-223.

GRDC GrowNotes Sorghum Northern Region 5. Nutrition and fertiliser

Figure 28. Resources page summarising the database, useful links and publications.

Contribution to the Smart Farming Partnerships outcomes Explain the contribution that this project has made to the Smart Farming Partnerships outcomes (as detailed in Section 2.4 of the Program Guidelines).
QUT to list the outcomes from the project plan and then each group address their own

Project finances

Progress against Project Budget

Was the receipt of grantee and project partner co-contributions in accordance with the Project Budget provided in the Project Plan?	Yes ☒	No ☐
If there is a variance of more than 10% between the actual receipt of co-and the Project budget, please explain the reasons and what is being done to address the issue. What are the implications, if not addressed and what does this mean for the Project activity in terms of outcomes?		
Was Project expenditure in accordance with the Project Budget provided in the Project Plan?	Yes ☒	No ☐
If there is a variance of more than 10% between the actual receipt of contributions and / or expenditure and the Activity Plan budget, please explain the reasons and what is being done to address the issue. What are the implications, if not addressed and what does this means for the Activity in terms of Activity outcomes?		

Is there any other information you think we may be interested in for this project?
NA

Attachments

Attachment 1: A two page Project Summary –summarising the key findings and outcomes of the Project.
Attachment 2: A list of all Project materials including all intellectual property created or arising over the life of the Project.
Attachment 3: A report of all assets created or acquired during the delivery of the project.

Attachment 1

Project Summary

Project title

Unlocking the true value of organic soil amendments, an innovative farm- ready tool for the effective management of manures and composts into farm fertiliser budgets for environmental, soil health and economic sustainability.

Partner organisations

Queensland University of Technology, University of Queensland, Latrobe University, Deakin University, Meat and Livestock Australia.

Project summary

The integration of plant nutrients released from organic soil amendments into farm fertiliser budgets allows not only for the reduction of synthetic fertiliser rates without compromising crop yield, but also multiple environmental and soil health co-benefits. This project provides farmers, agronomists and suppliers of manures and composts with a decision support tool for integrating organic amendments into farm nutrient budgets.

Objectives

On-farm field validation and demonstration sites from the Queensland to Victoria across vegetables, cotton, cropping and pasture showcased the tool and provide case studies of reduced fertiliser use and cost reductions, yield benefits possible from using organic amendments, and potential additional soil health and sustainability benefits. The Organic Amendment Nutrient calculator was developed using the data generated from the lab and field analysis, and incorporated farmer feedback from the workshops.

Key activities

Overall the project tested 65 different organic amendment types across 20 different field trials over four years. Sites were located from Roma in Queensland, through to Geelong in Victoria, spanning the beef, dairy, irrigated and dryland cropping and intensive horticultural industries. A common methodology was used across the sites, a combining laboratory analysis and farmer field trial and demonstration sites. The Organic Amendment Nutrient calculator was developed using the data generated from the lab and field analysis, and incorporated farmer feedback from the workshops.

The project combined national coordination and engagement with OA generators (producers, handlers, and suppliers) with field trials in cotton and irrigated broadacre crops, high-value vegetable systems and intensive horticultural crops and broadacre dryland grain and fodder crops to generate the nutrient release curve calculator/phone application to allow farmers to confidently use organic amendments from a range of sources in a variety of soil types.

Outcomes

The major findings, benefits to Australian agriculture and outcomes for policy makers are as follows:

1) The variability of OA products remains the key barrier to their wider incorporation into farm nutrient budgets. Even using best practice of nutrient testing, there is a mismatch between how they are sold, transported and applied (per meter cube fresh weight), and how their nutrient contents are reported (kg per dry weight). As such moisture content and bulk density are the two largest variants of what ends up on the farmer field – and neither are reported well.
2) Across all trials, yields from all trails responded either conventional fertiliser or organic amendments, with the dryland trials showing the least response and irrigated the most. Organic amendments increased biomass yield by 15% compared to unfertilized plots, and overall increased biomass by 8% across all treatments. Accounting for the nitrogen applied in the OA's led to a small gain in biomass overall (+4%), but with wide variations between individual crops. Distinct multi-year benefits were only evident in two of the trials, with variations in crop rotation and seasonal conditions masking any benefits at the other sites.
3) In the heavy clay soils of the irrigated cotton growing areas, OA's may preserve co-applied urea- N which could be available for use by subsequent rotational crops, an important consideration for medium term crop management. Cotton yield increased with annual poultry litter application, generating an additional potential income of $2000/ha over three years.
4) Trials in high-value horticulture confirmed that organic amendments (OA) are a valuable source of nutrients for early crop production, and accounting for these nutrients could reduce fertilizer inputs by up to 60% while maintaining yield. This benefit saved growers up to $2,600 /ha/year in fertilizer costs and improved nitrogen-use efficiency, as well as increasing soil health. However this came at an environmental cost – with the combination of OA's and mineral fertiliser increasing N_2O (potent greenhouse gas) by up to 50%.
5) Trails in the broadacre dryland cropping and fodder showed a more varied response to OAs as yields were driven more by seasonal conditions. However the large-scale field trials showed that combined use of OAs with reduced mineral fertilizer rates can provide yields that are similar to those obtained with standard mineral fertilizer application rates.
6) The calculator can be found here: https://oa-nutrient-calculator.netlify.app/.

Implications

This project again made very clear and promoted that using OAs needs to move away from a 'waste disposal' mindset to one of nutrient and soil management. This includes the need for farmers to have meaningful analytical test results for OAs they are going to use, as well as the use of appropriate spreading equipment that achieves satisfactory product distribution at the set rate.

The standardisation of research into national and cross-industry consistent and compatible frameworks, methodologies and databases is critical for addressing the wicked issues of sustainable food production and resource management. Clearly defining the trade-offs and benefits of organic amendments for Australian agriculture is becoming more critical as the de-carbonisation of the economy looks to divert OA's away from traditional disposal practices like land application (for manures) or landfill (for FOGO) and into bioenergy. Only by assessing the true-value of these OA's for nutrition and soil health can adequately informed polices be developed.

Attachment 2

Project materials including intellectual property

Please list all Project materials including all intellectual property created or arising over the life of the Project.

Institution	IP
Overarching project (Queensland University of Technology)	
OA generators (Producers, handlers, and suppliers) data collection and extension (University of Queensland)	
Cotton and Irrigated broadacre crops research, demonstration trials and extension (Deakin University)	Soil and plant datasets as submitted to Queensland University Technology from the following field sites: • Widgelli • Gundaline Station • Benerembah
Southern Vegetable systems and intensive horticultural crops research, demonstration trials and extension (La Trobe University)	None
Northern Systems and winter grain crops research, demonstration trials and extension (Queensland University of Technology and University of Queensland	
Nutrient release curve calculator/phone application from various organic amendments and soil types (Queensland University of Technology)	

Attachment 3

Project media, communications and extension materials

Please list of all media, communications and extension materials produced and all extension activities held over the life of the program.

Media, communications and extension materials	Date produced/published	Purpose
EXAMPLE: Pamphlet on Soil pH demonstration site		*To inform stakeholders about the demonstration site and how it will be monitored to encourage greater participation*
Farmer meeting in Roma, jointly organised and supported by AgForce, Organic Nutrients and UQ - CROWN	December 2018	To inform growers and agronomist consultants about the potential benefits of using composted manure products, and the trial about to be established in Roma.
Farmer meeting in Pittsworth, jointly organised and supported by AgForce, Organic Nutrients and UQ - CROWN	29/3/2019	To inform growers and agronomist consultants about the potential benefits of using composted manure products, and the series of trials about to be established in Felton, Dajuan and Mulgowie.
Crop Consultants Australia Soil Health	22/8/2019	Discussion with agronomists about benefits of poultry litter on soil health and fertilizer replacement value of animal manure.

Workshop, Griffith, NSW		
Two presentations given at the Annual Australian Organics Recycling Association (AORA) Conference in Perth	1-3/5/2019	To inform the commercial organics recycling industry about the start of the project and outcomes of previous trials that demonstrated the agronomic, economic and environmental benefits of accounting for nutrients supplied with organic amendments.
Subsoil Manuring Seminar in Toowoomba, organised by UQ - CROWN and supported by AgForce Queensland, Organic Nutrients and Tilco	12/8/2019	To inform growers and agronomists about the potential benefits of using raw and composted manure products for deep soil amelioration.
IREC Farmers Newletter (2 articles)	2019 Spring Edition 202 22/9/2019	To inform farmer member stakeholders about the start of the project and outcomes at Whitton field site.
UQ - CROWN organised and hosted a panel discussion entitled 'How can we translate SOM research into improved farming practices?' as part of the 7th International Symposium	9/10/2019	To facilitate the transformation of research outcomes related to soil organic matter and organic soil amendments into practice change on farm.

on Soil Organic Matter, held in Adelaide		
Field trip to Langhorn Creek trial site as part of the Symposium	11/10/2019	To present the project to domestic and international delegates of the Symposium.
IREC Annual Field Day presentations 2 fliers and booklet (2 articles)	21/1/2021	To inform IREC farmer members about project results from Benerembah and Gundaline Station field sites
Published article in Australian Organics Recycling Association (AORA) newsletter	30/1/2020	To inform the organics recycling industry about the project
Project updates published on IREC website	June 2020	To inform IREC members about overall project results
Field Walk: National Vegetable Extension Network	Celery field trial at Baxter, Vic, 22/10/20	To introduce key stakeholders at AusVeg, Food & Fibre Gippsland, Vegetable Soil Wealth Program, VegNet, and regional vegetable growers to the project, and demonstrate treatments and methods of data collection in the field. (Audience: limited to 9 attendees due to COVID restrictions) 

Field Meeting: Strawberry fruit growers and Berries Australia	Strawberry field site at Millgrove, Vic, 13/11/20	To introduce strawberry fruit growers and extension networks to the project, the use of organic amendments in the industry and the usefulness of the nutrient calculator app. (Audience: limited to 7 attendees due to COVID restrictions).
Webinar: 'Compost calculator: knowing the value of organic amendments in your vegetable nutrition program in Victoria'. Flyers and webinar video posted on internet.	National Vegetable Extension Network, Victoria Northern, Western and South Eastern, 17/2/21	To inform stakeholders about the project, detail how project will benefit stakeholders, get feedback from stakeholders on current organic amendment practices in industry and how they might use new tools developed in the project. Ninety-four percent of respondents attending the webinar said they were more informed about making decisions on the use of organic amendments, while 68% of growers said they would change practices based on the information they received. (Registered Audience: 40 vegetable growers in Victoria). https://www.ausvegvic.com.au/events/event/compost-calculator-knowing-the-value-of-organic-amendments-in-your-vegetable-nutrition-program-in-victoria/ https://www.soilwealth.com.au/imagesDB/events/Compostcalculator-knowingthevalueoforganicamendments.pdf https://www.soilwealth.com.au/resources/webinar-recordings/compost-calculator-knowing-the-value-of-organic-amendments-in-your-vegetable-nutrition-program-in-victoria/
Parna and Cotton Soils Workshop Yanco Riverina Soils Science Society Australia Meeting	29/4/2021	A presentation to soil researchers on the effect of poultry litter on nitrogen mineralisation and soil health when applied to cotton soils in the Riverina.
Project updates published on IREC website	June 2021	To inform IREC members about overall project results
Posters (2) presented virtually at Australian and NZ Soil Science Society Conference, Cairns, QLD	June 2021	Disseminating project information to academic community
Field Walk: Strawberry and potato nursery industry	Strawberry field trial at Toolangi, Vic, 1/7/21	To introduce key stakeholders at the Victorian Strawberry Industry Certification Authority, Australian Seed Potato Industry Certification Authority, and the Toolangi Certified Strawberry Runner Growers to the project, and demonstrate treatments and methods of data collection in the field. (Audience: 10 attendees due to COVID).

Field day at Goovigen, jointly organised and promoted by Fitzroy Basin Association and UQ - CROWN	1/9/2021	To inform farmers and agronomists about the project in general and the trial at the farm in Goovigen
Article published in Australian Cottongrower	October 2021	Disseminating information about Gundaline trial to industry stakeholders
Phosphorus webinar contribution to UQ (Biala) Phosphorus webinar	November, 2021	Dissemination and collaboration through mini workshop
UQ - CROWN organised promoted and hosted a webinar titled '*Phosphorus Supply from Organic Amendments'*	1/12/2021	To inform project partners and collaborators about the potential of organic amendments to supply P for plant nutrition purposes
Article Australian Berry Journal: 'Reducing fertiliser costs with compost and manures in strawberry and other crops'	Australian Berry Journal, Autumn 2022-Edition 10, pg 81, 2/3/22	To inform stakeholders in the berry industries (strawberry, blueberry, raspberry, blackberry, red currants) about the project, detail how project will benefit stakeholders and communicate preliminary results to growers. (Distribution: 650 growers Australia-wide) https://issuu.com/berriesaustralia/docs/ba_aus_berry_journal_ed_10_autumn_22
Field Day: 'Reducing fertiliser costs with more efficient use of organic soil	Strawberry field trial at Toolangi, Vic, 3/5/22	To communicate results from the project to strawberry growers, and provide an in-field demonstration that use of the nutrient calculator app can save them $1,300-2,600/ha in fertilizer costs. (Attendees: 18 local strawberry growers)

amendments’		
Article Australian Berry Journal: ‘Evaluation of sustainable fertilisers in strawberry and other crops’	Australian Berry Journal, Winter 2022-Edition 11, pg 65, 3/6/22	To communicate results from the project to berry grower stakeholders and update them on progress of the nutrient calculator app. (Distribution: 650 growers Australia-wide) https://issuu.com/berriesaustralia/docs/winter-2022-abj-web
Presentation given at the Annual Australian Organics Recycling Association (AORA) Conference in Adelaide	27-29/6/2022	To present the prototype of the Nutrient Calculator app to the commercial organics recycling industry
Conference presentation: ‘Unlocking the true value of organic soil amendments Slides posted on internet	BerryQuest International, 27/7/22	To inform Australian berry growers (strawberry, blueberry, raspberry, blackberry, red currant) about the project, present the nutrient calculator app, and seek feedback on its use from industry stakeholders. (Audience: 480 delegates) https://berries.net.au/wp-content/uploads/2022/08/260722-David-Rowlings.pdf
Conference presentation: ‘Has the berry industry met its obligation to help save the planet?’	BerryQuest International, 27/7/22	To inform Australian berry growers of current and future international regulations on the use of nitrogen, the impact of its non-strategic application on the environment, and the benefit of using tools like the nutrient calculator app. (Audience: 480 delegates) https://berries.net.au/ian-porter/
Field day at Goovigen, jointly organised	30/8/2022	To demonstrate and teach farmers about visual soil assessment as part of healthy soil assessment

and promoted by Fitzroy Basin Association and UQ - CROWN		
Virtual oral presentations (2) at National Agronomy Conference, Toowoomba and 2 x 4 page conference papers published	September, 2022	Disseminating project information to academic community
Journal paper published Nutrient Cycling in Agroecosystems	December, 2022	Disseminating project outcomes to international scientific community
Journal paper published Agronomy Journal	February, 2023	Disseminating project outcomes to international scientific community
UQ - CROWN organised promoted and hosted the Great Aussie Composting Roadshow with events in Colac, St Arnaud, Shepparton, Griffith, Maitland, Tamworth, Pittsworth, Dalby and Beaudesert	6-17/3/2023	To inform intensive animal industries and other interested parties about the benefits of composting and use of compost products, including nutrient supply and the Nutrient Calculator app

Attachment 4

Project assets

Please report all physical assets created or acquired during the delivery of the project

Asset	**Approximate value (as new)**	**Who paid for it**	**What will happen to this asset**
EXAMPLE: 5 Soil moisture probes	*$350 each = $1750*	*Paid for out of Commonwealth grant money*	*Soil moisture probes will be kept within the Sandy Creek Landcare group (who are project partners) and used for future soil erosion work*
Dehydrator oven	$7645	*Paid for out of Commonwealth grant money. Transferred, with permission from Commonwealth project manager, from travel budget allocation due to COVID restrictions.*	Oven will be kept by CeRRF, Deakin University in Griffith and be used for future soil and plant sample preparation.
CI600 Root scanner	$24, 965	*Paid for out of Commonwealth grant money. Transferred with permission from Commonwealth project manager, travel budget allocation due to COVID restrictions.*	Root scanner will be kept by CERRF, Deakin university and used for future root-soil nutrient interactions research in irrigated agricultural on-farm trials